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EDITORIAL.

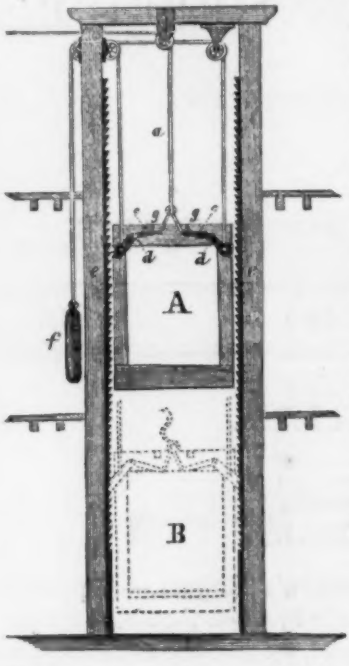
ITEMS AND NOVELTIES.

The Hoosac Tunnel.—Mr. Latrobe's Report.—A possible misconstruction of some remarks, made by us on the above subject in our last issue, having been suggested, we take the earliest opportunity of explaining: that, feeling, as we must, a sincere respect for Mr. Latrobe and his professional ability, it would be the furthest thing possible from our intentions to speak of his opinions with anything but respect, even when we are not ready to support his views in every particular.

If, therefore, any phrase we have used should have an air of irony, it is, in our estimation, equally unfortunate and opposed to our intention. We should, for our own part, never have imagined that any such explanation as the above was needed, but our attention having been called to the subject, we consider it equally due to Mr. Latrobe and ourself to make it.

That a playful accusation of not reading the *Journal*, should be supposed to cast a reflection upon any person or thing but the *Journal* itself, for failing to secure readers, never entered our mind, and, indeed, we sincerely hope that the unfortunate construction, already mentioned, has not occurred to any other than the one of our friends who has suggested it to us.

Safety Hoisting Apparatus, exhibited at the meeting of the Franklin Institute, June, 17th, 1868. In the drawing, A is the hoisting cage or platform on which the load is placed, *c c* are two levers having fulcra at *d d*, and provided at their outer extremities with teeth which take into the racks *e e*, extending the whole height of the hoistway, and attached to vertical timbers provided to receive them, and which, at the same time, serve as guides to the cage.



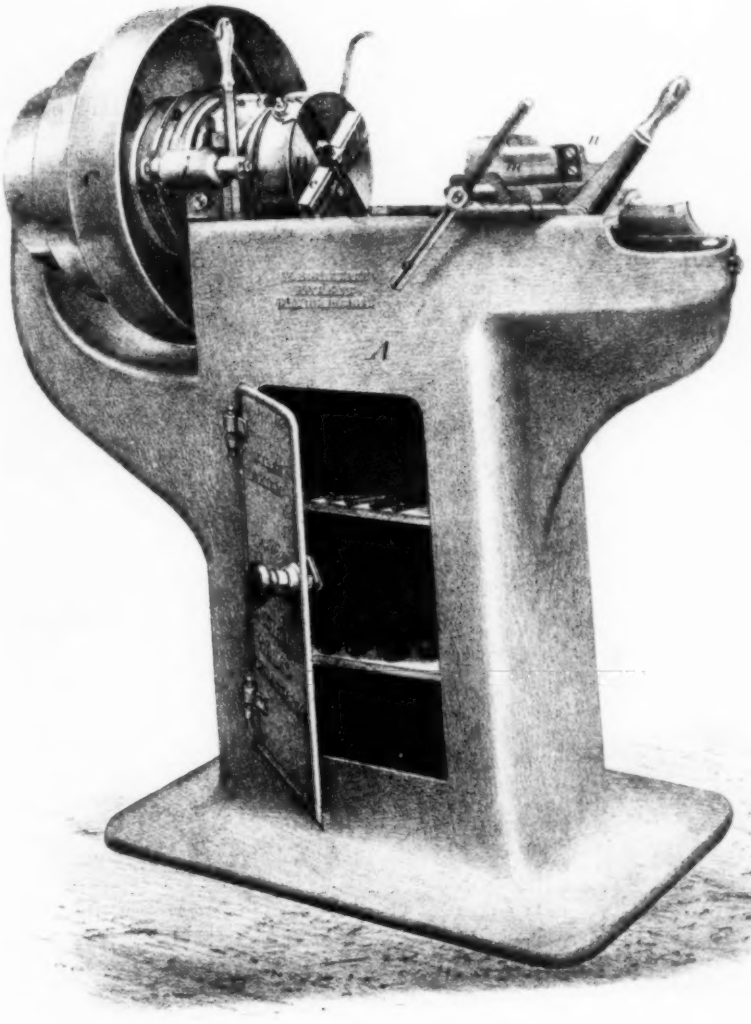
The minor ends of the levers, *c c*, are connected with the main chain or rope, *a*, by which the hoisting is done; to the outer ends of these levers are attached ropes or chains which, passing over leading pullies, are connected with a counterbalance weight, *f*.

The stops, *g g*, are so arranged as to allow the levers, *c c*, sufficient motion to withdraw the teeth from the racks, and to permit the cage to pass freely up and down the hoistway.

Should an accident happen to the hoisting chain, the weight of the cage instantly comes upon the counterbalancing ropes, and the levers being drawn out, the teeth take into the rack and the cage is prevented from falling.

The use of a counterbalance weight is of further service in reducing the work to be done by the hoisting engine. This apparatus is patented by Messrs. Merrick & Sons, of this city.

Some Novelties in Machine Tools.—We lately spent a morning very pleasantly in going over the admirably arranged works of


A

Messrs. Bement & Dougherty, at Twenty-first and Callowhill Streets, in this city. The special object of our visit was an immense vertical boring and turning machine, which had just been completed for the United States Navy Yard at Charlestown, Mass.

Beside this huge mechanical monster, weighing no less than 140,000 pounds, and capable of licking into shape a mass of iron 23½ feet in diameter, we saw and took note of various other processes and things which will be of no little interest to our readers generally.

One of these we shall describe at the present time, and others in subsequent numbers.

We select, as the first, an 1¼-inch opening die bolt cutter, with self-oiling arrangement.

Fig. 1, Plate I., is a cut from a photograph of the machine. Plate II., Fig. 2, is a longitudinal section of the spindle. Fig. 3, a transverse section of the spindle, showing internal gear and segments. Fig. 4, a transverse section of the spindle, showing the reversing spring. Fig. 5, a front view of the spindle. Fig. 6, a view of the spindle head. Fig. 7, a vertical section of the pump.

Similar letters refer to similar parts throughout the several views. A is a hollow cast iron frame with shelves and closet door, provided with suitable bearings for the hollow cast iron spindle, B, on which is secured a cone-pulley, C, in place of which gearing is used for larger machines. A disk, D, with an internal gear in front, and a flange on the outside is fitted snugly on the hub of the cone-pulley, C, but so as to turn freely, its motion being limited by the ends of the segments, E, striking against the spindle, B. In the rear of the disk, D, is a coiled spring, one end of which is fastened to the cone-pulley, and the other end to the disk, D. The segments, E, are keyed on the ends of eccentric steel-spindles, *a a*, which turn in the enlarged part of the spindle, B; the other end of the eccentric spindle works in a slot of the square steel block, *b*, on which is the adjustable die-holder, *c*, the reversible die, *d*, is bolted to the die-holder, *c*. The spindle-head is also provided with two tap-holder jaws, *e*, thus obviating any changing for tapping nuts. When the dies are to be opened the handle, *f*, on the brake, *g*, is moved in a vertical position, thus clamping the flange on the disk, D, by the brakes, *g* and *h*, which slide in a bearing, *i*. The disk, D, being held from revolving, causes the segments, E, to turn, and with them the spindles, *a a*, thus raising the die-holder blocks with the dies. By turning the handle, *f*, back again the coiled spring forces the disk back

again, and with it the segments into the cutting position. The segments are provided with a piece of leather on one end to prevent the noise when being forced back by the spiral springs. The pump, F, is fastened in the reservoir cast for it in the frame. The hollow plunger, *k*, has a small roller on top, and is forced down by an eccentric on the spindle, B, and is held up against it by a spiral spring, thus effecting a reciprocating motion; the oil is strained by a seive, thus allowing it to be used over and over again.

The tapping or sliding-head, G, Fig. 1, is forced up by a lever, *l*, having a pawl connected to it which works in a single rack fastened on the end of the main frame, central between the slides. The weight of the lever will keep the pawl out of the rack, allowing the sliding-head to be drawn back by hand. The nuts to be threaded are held between the sliding jaws, *m* and *n*, Fig. 1, by a right and left-hand screw worked by the spider, *o*.

[We owe the three following items to the kindness of Prof. De Volson Wood:]

The Tunnel at Washington Street, under the Chicago River, is progressing favorably. The old company commenced their work close to the river, and excavated vertically down; but the present company commenced at the ends and are approaching the river both ways. The main tunnel forms a double track passage, and a separate tunnel in the same excavation a passage way for footmen.

A coffer-dam encloses half the width of the river, and an open cut will be made to the centre of the river, and the tunnel built to the end of the excavation and closed.

The water will then be let in and the other half enclosed in a similar way, and the remainder of the cut made and the tunnel completed. It will probably be ready for use next spring W.

Canadian Mining.—There are large mining interests in Canada, which, if properly encouraged by the Government, will doubtless be rapidly developed, and bring much capital and public enterprise into the dominion. A large iron mine, pleasantly located on Lake Marmora, was opened forty or fifty years ago, but was soon abandoned. Last year, a company was formed, composed largely of American stockholders, for working this mine. They shipped their first ore in July, 1867, and this year they are moving several thousand tons. The mine is above the level of the lake, and they are now working 200 to 300 feet from it. The ore is taken on cars from the mine to the river Trent, about eight miles, where it is dumped on barges and shipped twenty-seven miles to the Cobourg

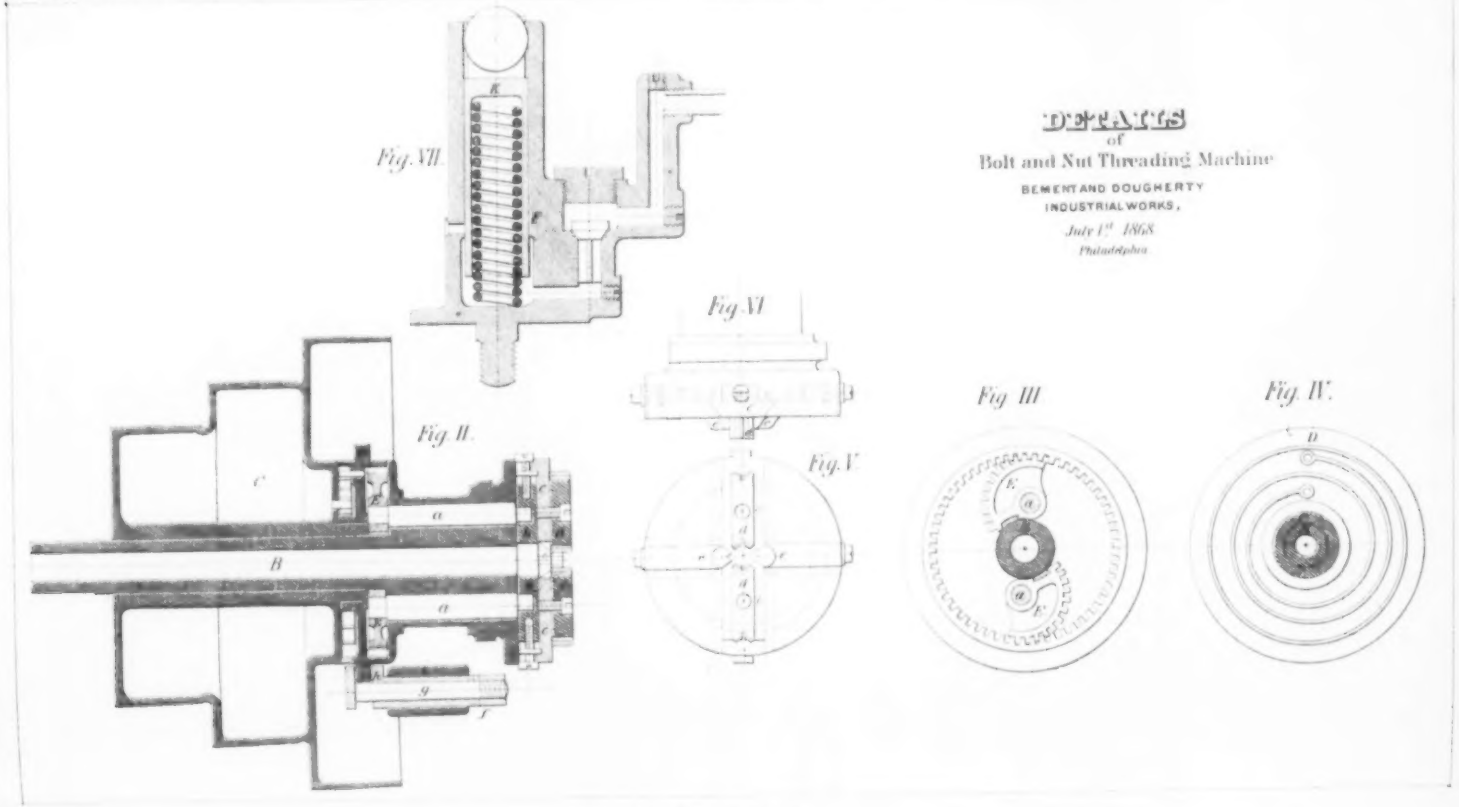


Fig. VII.
Fig. II.
Fig. VI
Fig. V.
Fig. III
Fig. IV.
DETAILS
of
Bolt and Nut Threading Machine
BEMENT AND DOUGHERTY
INDUSTRIAL WORKS,
July 1st 1868
Philadelphia

and Peterborough railroad; thence it is taken on cars fourteen miles to Cobourg, where it was transferred to sailing vessels and shipped to furnaces in New York and Pennsylvania. The Madoc gold mines are twelve miles east of Lake Marmora. I just saw over forty dollars worth of the metal, which was taken from half a ton of the ore, but practically, they have not succeeded in reducing it at the mine. A gentleman, who claims to be familiar with the business, thinks that the ore is similar to the Colorado ore, and when reduced in the same way as the latter, will yield large profits.

Large iron mines still further east were opened last year with a fair prospect of paying well.

The gold mines of Nova Scotia are generally good. In one district, they produced last year over $1,600 for every male person in the district. W.

Loss of Power in Steam Generators.—Steam has revolutionized many kinds of business during the past thirty years, by cheapening the products of industry, but could we utilize one-fourth the total heat in the fuel used for generating steam, and for domestic purposes, it would produce a greater revolution in the *economy* of business than has yet been witnessed. According to Andrews, one pound of anthracite coal has sufficient heat when burned, to raise 14,220 pounds of water one degree of Fahrenheit's scale, which multiplied by Joulé's equivalent, 772 foot-pounds, gives 10,977,840 foot-pounds. If the pound of coal produced this result in one hour, it would be equivalent to 5½ horse-power.

A good engine will produce a horse-power from four pounds of coal, and the very best from two pounds; thus utilizing 9 per cent. in the latter, and 4½ per cent. in the former. W.

American and English Railway Carriages Compared.—We extract the following from a Buenos Ayrian paper, being part of a letter written by the (English) traffic manager of the Northern Railway of Buenos Ayres:—

"We find also that three American carriages only weigh one ton more than two English make; the three American carriages seating seventy-two passengers more than the two English, against the same amount of dead weight.

"Their expenses of repair amount during the past ten months to $40.866, currency, or $4.086 currency, for each; whilst during the same period, the American carriages have not cost anything for repair, and are at present in better condition than those made in England, although they have been in constant use since the line

was first opened. I may also remark that their chilled iron wheels scarcely show any perceptible wear.

"The American carriages are in every respect a better and more comfortable carriage, requiring less than one-half the power to propel them that is necessary for the carriages of English construction. It has also been proved that the English carriages are much more injurious to the permanent way and works, and likewise, in proportion, more destructive to themselves than those of American construction." (Signed) J. BOYD THOMSON,

of Glasgow, Managing Agent. B. A.

Direct Acting Circular Saw Mills.—Of late years, fast running engines for operating lumber mills, have obtained firm footing in the west. Small cylinders, with short stroke of piston, and large steam openings, are frequently found running at the rate of *five to six hundred revolutions per minute*, for driving large circular saws, the saw being on the crank shaft, and requiring the engine to be driven the same number of revolutions as the *saw*. This class of engines is mostly built at Salem, Ohio, at the Buckeye Shops, and at the Salem Iron Works. An engine lately built by the latter firm for a party in the State af Michigan, was of the following dimensions: Diameter of cylinder, sixteen inches; stroke of piston, twenty-four inches; running two hundred revolutions per minute, and driving two fifty-four inch circular saws (by belts) seven hundred revolutions per minute. One of these saws containing thirty teeth was tested, and the chips (not dust), measured one-eighth of an inch each, which gives a cut of three inches and six-eighths to each revolution of the saw, or at the rate of two hundred and eighteen feet per minute; but allowing for time to run back the carriage and shift the log, this rate will be reduced fully one-half; and yet this seems almost impossible. However, we have seen and measured some of the chips that were forwarded in a letter to Messrs. Sharp & Davis, of the Salem Iron Works. The circular saw was made by Mr. Henry Diston, of Philadelphia, to the order of Messrs. Sharp & Davis, of Salem, Ohio. This engine and saw are guaranteed to cut fifty thousand feet of lumber in ten working hours

Another thing in these steam mills, is the small amount of steam room or boiler. Below is the result of a trial made a few years ago by Messrs. Sharp, Davis & Bonsall, of the Buckeye Machine Shops, of Salem, Ohio.

"We attached two of our engines to a single boiler sixteen feet long, forty inches in diameter, with two fourteen inch flues. One

of the engines with a six and a half inch bore, seventeen inch stroke, and attached directly to a mulay saw, cut, from twenty-three poplar logs, 12,229 feet, all inch boards except 1,100 feet of one and a half and two inch plank. The other engine with a six inch bore, fourteen inch stroke, and attached directly to a fifty-four inch circular saw, cut from forty-three poplar logs, 14,948 feet, all inch boards. The work was all done between the hours of six o'clock, A. M., and 5-10 P. M., of the same day. Running time on the mulay mill, nine hours; and nine hours four minutes on the circular mill—which time included putting on and off the logs. Thus we have 27,177 feet of lumber sawed in nine hours and four minutes by the steam generated from *one* boiler sixteen feet by forty inches, two flues—being equal to only 240 feet of fire surface. The only fuel used during this trial was two and a half cords of slabs and poplar bark, about equal quantities of each. As to the amount of fuel thus used, we claim no particular saving; for, to burn that amount of fuel nnder that boiler in so short a time, a very lively fire must be kept up; and to burn the same fuel in the same time under a similar boiler of fifty per cent. more fire surface, fifty per cent. more steam would be generated, and a corresponding amount of sawing done."

The engine is placed by the side of saw-frame, and its shaft extends across the frame and receives the saw directly on its outer end—both engine and saw making the same number of revolutions. The boiler is usually placed so as to bring the engine immediately between the boiler and saw-frame, but it can be placed so as to be most convenient to the fuel. The speed of these mills is from 400 to 500 revolutions per minute, and as high as 700.

Occlusion of Gases by Metals.—We have, at former times, made brief notice of this subject, in connection with the theories now best supported, as to the chemistry of acieration or the manufacture of steel from wrought iron; and also in connection with the subject of Celestial or Astronomical Chemistry, and we now propose to make a more complete résumé of the whole matter, in the shape of an abstract prepared from the address on this subject, delivered by Wm. Odling, M. B., before the Royal Institute, May 17th, 1867, and printed in the volume of *Proceedings*, just published.

The fact that various metals heated to a point in the vicinity of redness, allowed certain gases to permeate them, first noticed by Deville, in the case of iron and platinum, was proved by Graham to exist in a far greater degree and at a lower temperature with palladium, which allows some hydrogen to pass at 240°, and a con-

siderable flow at 265° and above, though impervious to air even at a red heat. This action, was also shown by Graham to differ entirely from the ordinary phenomena of transpiration and diffusion, and to involve an absorption of the gas by the metal, dependant upon special relations between the two.

Many of these relations have been carefully tested, and some of

	NAME OF GAS OCCLUDED.	VOLUME OF GAS GIVEN OFF IN PER CENT. OF VOLUME OF METAL.
Platinum wire from fused metal.....	Hydrogen	21·
Same wire drawn to four times the length.	"	17·
Spongy platinum.....	"	148·
Wrought platinum, one specimen in several experiments.....	"	553·493·383. Av. 476.
Palladium foil heated to 245° and cooled, treated as before.....	"	52·600 or 526 vols.
Palladium foil heated to 90°–97° for three hours, cooled and treated as before.	"	54·300 or 643· vols.
Palladium sponge heated to 200° &c.....	"	68·600 or 686 vols.
Palladium foil at common temperature absorbed and yielded by same treatment.	"	37·600 or 376 vols.
Palladium foil absorbs also certain liquids.	Water, Alchohol, Ether,	0·1 per cent., 0·15, and 0·55
Copper wire.....	Hydrogen	30·
" sponge.....	"	60·
Gold—assay cornettes...	"	48·
" " "	Carbonic oxide	29·
" " "	" acid	16·
" " "	Air, almost all N.	20·
" " "	Natural gas expelled by first heating in vacuo. H & CO.	212·
Silver wire.....	Hydrogen	21.
" "	Oxygen	74·
" sponge.....	Hydrogen	92·
" "	Oxygen	722·
" "	Carbonic acid	52·
" "	Carbonic oxide	15·
" leaf in air.....	Oxygen, nitrogen	137· and 20·
Iron wire.....	Hydrogen	46·
" "	Carbonic oxide	415·
" "	Natural gas expelled by first heating in vacuo. CO.	700· to 1250·
Meteoric iron from Lenarto	Hydrogen 85 p. ct. of entire yield, rest N and CO.	275·

the results will be found above, where we have arranged them in a tabular form, for the sake of brevity.

The substances mentioned were heated and allowed to cool in an atmosphere of the gas named, and were then again heated in a glass or porcelain tube, kept exhausted by a Sprengel air pump, the gas extracted being carefully measured.

Several of the facts expressed in the above table, are worthy of special note and consideration. Thus we see that wrought platinum absorbs on the average 476 per cent., or about five times its volume of hydrogen, but this is the bulk of the gas measured cold after its extraction. When it was absorbed, the temperature was about 1400 F., which would give it a volume fifteen times that of the mass of platinum, by which it was imbibed. To condense or compress the gas to this degree in a space otherwise unoccupied, would require a force or pressure of fifteen atmospheres, but this compression is accomplished in a space already occupied by one of the densest of metals, the interstices between whose ultimate particles we cannot conceive as occupying more than the $\frac{1}{1000}$th of its total bulk. To compress the fifteen volumes of gas into this space of $\frac{1}{1000}$th of a volume, would demand a force of no less than 15,000 atmospheres, or 225,000 pounds per square inch, and yet to this almost inconceivable power, we here see the atomic attraction between the particles of the metal and gas is proved equal.

But if this statement staggers belief even in the face of demonstration, what shall we say to the case of palladium, which absorbs not five but 643 volumes of the same gas.

In this latter case, the gas so occluded, is in part lost at ordinary temperatures and conditions of atmospheric pressure, but with platinum the gas occluded is held firmly even in a vacuum at 220°, and even at a heat a little below redness. At a temperature sufficient to soften glass (500°), 1·72 c. c. of H were collected in ten minutes, and in a combustion furnace 8·2 c. c. in an hour.

The temperature required for absorption of hydrogen by platinum is much below that at which the gas is again released; thus, some foil absorbed 76 per cent. at 100°, and 145 per cent. at 230°.

The condensed hydrogen has the properties of the nascent gas. Thus, palladium so charged, reduces permanganate of potash, bleaches iodide of starch, throws down Prussian blue from ferrocyanide of potassium.

The absorption of carbonic acid by iron, has a marked connec-

tion with the theory of acieration, as we have pointed out on a previous occasion, when this fact was first discovered, and applied in this explanation. At a low temperature in the cementing oven, also carbonic oxide (2 CO) is no doubt absorbed by the iron, and at a higher heat is decomposed, yielding part of its carbon to the iron for its transfermation into steel. Thus two equivalents of carbonic oxide (2 CO) liberate one equivalent of carbonic acid, and giving one of free carbon to the iron. The carbonic acid as it escapes produces the well known phenomenon of blistering.

We also see that wrought iron acquires in the process of manufacture, a change of from seven to twelve volumes of carbonic oxide, which it carries with it ever afterwards.

To the conclusions to be drawn from the presence of hydrogen in large amount in meteoric iron, we have alluded at some length before, and will at this time simply insert a reference to this former discussion (see Vol. 54, p. 16 of this *Journal.*)

The Brooks Insulator.—In our last issue we promised to give the results of tests made in our presence, in which the merits of the Brooks Insulator were compared with those of other forms. We will now give the tests made in Philadelphia, April 22, 1868. The testing instruments employed were a set of resistance coils, made at the Silverton Works, and a Ruhmkorff Galvanometer of admirable construction, whose delicacy was such that the contact of one finger, with a brass bending screw at one terminal, while a finger of the other hand rested on a copper wire at the other terminal, deflected the needle several degrees. The results are reduced to ohmads of resistance to make them comparable with the Silverton experiments, in which a far more sensitive galvanometer was employed, and a more powerful battery.

The constant of the galvanometer was first determined by passing the current of one of the sulphate of mercury cells described by Mr. Chester, p. 257, of our last volume, through a resistance of 10,000 units or ohmads and the instrument. This gave an actual constant for one cell of 6,160°, or for the entire battery of 151 cells, afterwards employed, of 930,160.°

One pole of the battery being then connected with 88 Brooks insulators, and the other through the galvanometer to the earth, a deflection of 8° was observed, giving for each insulator a deflection of $\frac{8}{88} = \frac{1}{11}$ of a degree, which represented a resistance under the conditions described above, of 102,317,600,000 ohmads.

At the same date, a trial was also made with 22 earthenware insu-

lators, charged with paraffine by the same method as for the other insulators. The deflection in this case was 17° or $\frac{17}{22}$ per insulator, which being reduced as before, gives 12,037,365,902 ohmads.

There was then immediately a trial made with 22 glass and bracket insulators, the kind generally employed in this country.

The deflection here measured was 7852°, or $356\frac{10}{11}$ per insulator, showing a resistance in ohmads of 2,605,000.

The atmospheric conditions under which these experiments were made were as follows: It had rained steadily on the 20th and 21st until evening, when a fog formed and continued until 8 A. M. of the 22d, when the deflections were greatest, and were measured as before stated.

The Silverton tests on March 31st, the time of greatest deflection, reduced to ohmads, stand as follows:

United Kingdom Tel. Co.'s large porcelain...	4,087,500
Varley's double porcelain cup.....	8,270,000
British and Irish Mag. Tel. Co.'s porcelain...	2,725,000
United Kingdom's Tel. Co.'s small porcelain	3,270,000
Brooks' patent.....	40,875,000,000
" "	40,875,000,000
" "	163,500,000,000
" " lug for crossarm.....	54,500,000,000

Several points are here worthy of remark. First, the English tests give a higher actual resistance for the Brooks instrument than those made here. This is undoubtedly due to a better state of the weather. Such a favorable condition for putting to test the efficiency of insulators, as was furnished on April 22d, is, fortunately for the telegraph company, not often to be met with. Again we see that the various English insulators tested were ahead of our usual glass and bracket, while these in their turn were left, each further in the rear, by the Brooks apparatus.

The constant of this galvanometer made by Ruhmkorff, is, as we have already seen, 6160°, with a single cell through 10,000 ohmads, while that of Prof. Thompson, used in the Silverton tests, has a constant of 335° through 1,000,000 ohmads, or 100 times the resistance, thus showing that the delicacy of the English instrument was five times as great as the French.

There is, indeed, no question, that in all such matters, if connected with the application of scientific principles and accurate measurements to the practical working of telegraphic lines, the English are decidedly in advance of all other nations. On the other hand, there

are a vast number of ingenious contrivances and simple ways of securing good results, in constant use here, which are unknown abroad.

Effect of Surface on Radiation.—In a late address before the Royal Institution, Mr. Balfour Stewart employed the following interesting experiment. A cannon ball with chalk marks upon it, and a tile with a pattern in white and black upon it, were heated to redness and viewed in a darkened room, when it was found that the black parts of both objects emitted more light than the white ones.

Hard Water.—Dr. Clark's most ingenious process for softening hard water containing carbonate of lime, dissolved in excess of carbonic acid, by adding an additional amount of lime, which, taking up the free carbonic acid, caused all the carbonate of lime (insoluble in pure water), to be precipitated; has been thoroughly tried in London, but proves impracticable, on account of the enormous quantity of precipitate formed where such vast volumes of water were treated. This we learn from a paper read before the Royal Institute, by Mr. E. Frankland, Professor of Chemistry to that institution. In the same paper, we learn that one-third of a pint of milk contains more lime than two quarts of this very hard London water, so that any claim to importance as a source of lime to the system, is thus denied to that otherwise so objectionable beverage.

Editorial Correspondence.

LETTER FROM THE ABBÉ MOIGNO.

Paris, July 30, 1868.

A NOVEL and ingenious microscope has been invented by Signor Marco Caselli, of Rome. It consists of a magnifier, one of whose sides is silvered by precipitation with the aid of organic substances. If we place an object in front of this lens at a proper distance, we obtain a well magnified virtual image. Two convergences and one divergence contribute to produce the magnifying power:—1. The convergence of the rays entering the lens. 2. The divergence of these rays by the silver concave mirror at the back. 3. The convergence of these rays on quitting the upper surface of the lens.

The mirror-lens is placed horizontally, or slightly inclined, so as to

keep at a distance the image of the object. Above it, and fastened to the same pillar, is the horizontal diaphragm on which the object is placed; this is furnished with a screw and rack-work, so as to be raised or lowered at will. Above this, at a short distance, is placed a screen of white or almost colorless card-board, at an angle of 45 degrees, and pierced exactly over the centre of the mirror-lens, with a small hole, through which the image is seen. This card also serves to reflect light on the mirror-lens, and to make the image appear on a white ground.

With this microscope, there is no need of the usual lenses, nor mirror to light up the object, since the mirror-lens itself causes the light to converge on the object.

M. Richner, of No. 4 Rue du Hasard-Richelieu, Paris, has invented a very ingenious little apparatus, very much needed for announcing, by a bell, the arrival of the moment for mounting or winding up a moderator or a carcel lamp, especially for the moderator, in order to prevent the wick from smoking, becoming carbonized and being extinguished. The contrivance consists of, 1. A movable clip, which fits into the space between two teeth of the vertical rackwork of the lamp, and is furnished with slotted projections, into which fits the tail of a hammer or striker. 2. A bell, which the hammer strikes when the fall of the rack brings down the projection of the clip; this is placed always on the side opposite to that of the overflow drip, in order to prevent the oil from inundating the bell. When the rackwork is wound up, the tail of the hammer lets the projections of the clip pass by, this latter then assuming its natural position.

Two new steamers—the first of the kind ever built here—have just been launched in the very bosom of Paris. They have been constructed by M. Casimir Deschamps, for raising sunken vessels, and they received the names of *Le Persévérant* and *Le Bonespoir*. Their peculiar build and graceful form of rig, the difficulties under which they were built and launched, and the fact of M. Deschamps having been originally bred up as a sculptor, render the details of this vessel of practical interest to the mechanical world.

Both vessels are alike in size and rig; length 59 feet, breadth 9 feet 10 inches; depth 10 feet 6 inches, about 150 tons. Commenced on the 1st October, 1867, they were fully completed in May last, and launched, masted and rigged. The canal of La Villette, near which they were built is only 66 feet wide, so that the launching was attended with extreme difficulty. What is most extraordinary, is, that these ships of wood, strengthened by iron ribs, sheeted with

riveted iron plate, and covered with Stockholm tar, all complete, masts, sails, in fact everything necessary for sea, have sprung up as if by enchantment, without any master shipwright, engineer or mechanician. M. Deschamps made his drawings in a small, wooden office, put them to working scale, and executed them himself, aided by simple Parisian carpenters, joiners and smiths. On this comparatively gigantic work, he spent only £4,800, whereas the shipbuilders of Havre, Cherbourg and Nantes, demanded from £6,000 to £6,400 for the same work.

As the first of their kind, these boats are constructed upon a completely new and perfectly combined system. By their rounded form, which gives them more volume and stability, they remind us of the good steamers which ply directly between Paris and London. The hull is divided longitudinally into two portions, containing each thirteen chambers, separated by thick iron plate diaphragms, destined to contain alternately water and air; perfectly impervious to water or air, under a pressure of five atmospheres, they can remain separate or be made to communicate with each other at will. Two series of tubes, furnished with valves and a cock opposite each compartment, run along the whole of the deck, in the middle, and place the chambers in communication with the pumps which either exhaust the water or pump in compressed air. Each water tight compartment has, besides, a man-hole, so that the bottom can be inspected, or a boy can descend. Lastly, well-holes have been made, between the two longitudinal series of chambers, from distance to distance, traversing the whole of the ship from the deck to the water. These are for the passage of the chains, which are passed under the sunken vessels, in order to raise them.

The ends of these chains are wound round a very massive iron drum of a windlass, set in motion either by steam or manual power, and capable of lifting 25 tons. In order to raise a shipwrecked hull, either one or both of the vessels can be used according to circumstances. The method is very simple; the steamer is brought exactly alongside the wreck, and the compartments are filled with water sufficiently to sink the caissons to nearly the level of the water; the chains are then passed under the sunken hull, and wound tight by means of the drums. On the water being pumped out of the steamer's compartments, the wreck is raised from the bed of sand or mud which it occupied.

The interior dispositions of these ships are no less satisfactory. In the forecastle we find the captain's cabin 13 feet square; amidships,

the air and water-tight compartments; abaft, the engineer's and stoker's berths, the coal bunker, the boilers and engine. There are two boilers, one of five another of ten horse-power, and an American motor of ten horse-power, fitted with Giffard's Injector, &c. We are able to state, to his praise, that for boilers, engines and the rest of the machinery, as well as the propelling screws, M. Deschamps addressed himself to the most careful and trustworthy constructors. He has neglected nothing, and his spirited efforts we are sure will be crowned with complete success.

M. Caron (commandant), has published a memoir on the composition of a gaseous mixture serving for the oxyhydrogen light, and a new material to be substituted for the magnesia cylinders. He has found that these latter cannot resist, indefinitely, the intense heat produced by the combustion of ordinary coal gas mixed with oxygen. This volatilization of the magnesia may be due to the formation of reduced magnesium, which M. M. H. Deville and Caron found to sublime very easily. (This is the process now most in vogue for purifying this metal.) Considering that, in order to obtain the greatest light, the gaseous mixture should always contain an excess of hydrogen, the combustible and the reducer, M. Caron made experiments in which he measured the quantities of the two gases (pure hydrogen and oxygen), and fully demonstrated the above fact. When substances oxydized at a maximum, but capable of being reduced to a minimum by hydrogen, are exposed to high temperatures, and under the same conditions of the composition of the gases, we are certain to find, after extinction, that the portion of the pencil or cylinder, exposed to the flame, has been converted into an inferior oxide. Thus, for example, titanic acid, heated in oxygen to the highest temperature, does not melt; but submitted directly to the flame of a lamp (containing an excess of hydrogen), it melts immediately, and, yellow as it had been, becomes blue and sometimes black. A very curious phenomenon is also remarked. In regulating the gases so as to obtain the maximum of light, a burst of sparks proceed from the crayon, similar to those produced by iron burning in oxygen. This is, in fact, the titanic acid, reduced at first, but re-oxydized afterwards in the midst of air and aqueous vapor. The shower of sparks ceases immediately on slightly increasing the supply of oxygen. The tungstic, niobic, and tantalic acids possess equally this fusibility, even in a high degree, for when heated to a white heat in a platina crucible, by means of a Schlœsing blowpipe, they always melt if the flame contains an excess of hydrogen. They

crystallize on cooling, and become discolored. The titanates, tungstates, &c., with a magnesian base, also melt and turn black in the oxyhydrogen flame; all these substances are thus unsuited for lighting purposes. Silica, alumina, and the refractory earths melt and give out little light. After examining the effects of glucinium, the oxides of chromium, of cerium and of lanthanium, M. Caron tried silicate of zirconium, of which he knew the infusibility; but as he expected, the pulverized and agglomerated zircons gave very little light (which happens, in general, with all the silicates.) He resolved to try ZIRCON. According to Berzelius, this earth has the property of being infusible, and giving out a light of dazzling brilliancy in the flame of a blowpipe. This, M. Caron found to be true, and he has employed the same crayon in the flame of the oxyhydrogen jet, without the least sign of wear, volatilization, or even partial reduction. This is very important, for the incandescent matter must remain always at the same distance, and if the pencil wore away, the distance would increase and the light diminish.

The use of ZIRCON in the oxyhydrogen light, is a valuable discovery, for, in addition to its being unalterable, the light is superior to that of magnesia in the proportion of 6 to 5. Though, at present, rare, ZIRCON exists in many volcanic sands, and in great abundance in the zirconean rocks, near Mark, in the environs of Ilmeusea, at the foot of the Ural Mountains.

M. Caron has also found a very simple method of economising the substance, by only applying the zircon to that portion of the crayon exposed to the flame; the rest can be made of magnesia or even refractory clay. By compression, the zircon adheres to the other substance, and burning adds to the solidity of this adhesion.

Zircon crayons are made in the same manner as those of magnesia

F. Moigno.

[Preparations are now going on in New York for a practical trial of the new method for the manufacture of oxygen, by heating manganate of soda in alternate currents of air and steam.

We had also the pleasure of witnessing, in the laboratory of Dr. Doremus, various experiments conducted by him with the little pencils of compressed magnesia, referred to above by the Abbé Moigno. The pencils were unaffected by the air and remarkably enduring under the action of the flame of illuminating gas and oxygen, which was directed upon them.—Ed.]

Civil and Mechanical Engineering.

PNEUMATIC BRIDGE FOUNDATIONS.

By O. Chanute, C. E.

(Concluded from page 28.)

Busswill Bridge.—At the Busswill bridge, over the Aar, in Switzerland, both the abutments and the three river piers, were founded upon iron caissons, surmounted with masonry, and sunk to a depth of 49 feet below low water.

The caissons, weighing on an average 71,662 pounds, were rectangular, 13 feet 9 inches wide, 39 feet 4 inches long for the piers, and 35 feet 5 inches long for the abutments. The working chamber was 8 feet 10 inches high, and the sides of $\frac{3}{8}$ plate, stiffened by 26 iron beams supporting also the roof. The latter was but $\frac{1}{4}$ inch thick, and was found rather weak in the process of sinking, though strengthened by the 26 side beams, as well as by 9 transverse and 2 longitudinal iron beams.

Above the working chamber, a sheet iron skin of No. 14 plate, was carried up in order to form the coffer-dam, and protect the fresh laid masonry from the friction of the soil in sinking.

Each caisson was suspended by 12 screws, and the excavations extracted by a central dredge, working in a tube 6 feet 3 inches diameter of $\frac{3}{8}$ plate, while the two air chimneys (of which only one was used), were 2 feet $11\frac{1}{2}$ inches diameter, and $\frac{3}{8}$ thick.

As such light caissons would have buckled, and might have been crushed by the side pressure of the soil in sinking (the much stronger caissons at Kehl having been somewhat crippled, and required vaulting), brick arches laid in cement were laid inside between the side beams, before the process of sinking was commenced, so that the caisson was in fact a brick vault, surrounded by the iron work and supporting the pier.

The air compressing engine was made of two old locomotive cylinders, mounted on an oak frame, worked by an engine of 20 horse-power, erected on the left bank of the river. The air was conducted to the workings through cast iron pipes, with India rubber joints, laid on a temporary bridge built to expedite the transportation of materials.

With these arrangements, the five caissons were successively put

down, the masonry built, and the superstructure (erected upon one of the banks), rolled over the piers into place as fast as each pier was completed. The whole work was done in one year, and as will hereafter appear, at considerably less cost than bridges founded with tubes.

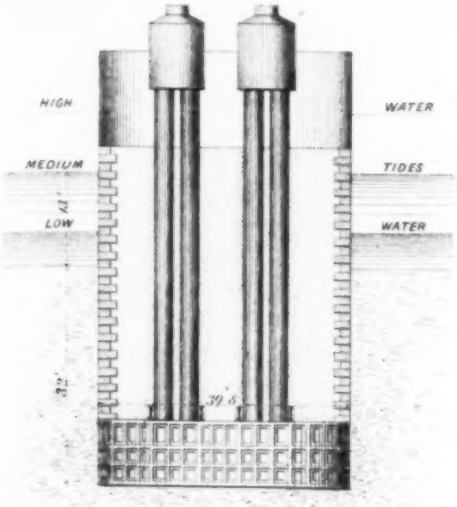
Scorff Viaduct.—At the bridge over the Scorff, at Lorient, built in 1862, by M. Croisette Desnoyer, as chief engineer, it was at first proposed to found the two intermediate piers, carrying the metallic spans of the viaduct (the approaches being of masonry arches), each upon two tubes of 14 feet 9 inches diameter, put down to rock, filled with cut stone masonry, as they were to be in salt water, and surmounted above low water by a masonry pier resting upon an arch turned over the two tubes. This arrangement was deemed necessary in order to insure stability, the lower chord of the bridge being 105 feet above the rock, at the deepest foundation.

The bids of contractors, for foundations, on the engineer's plans, exceeded his estimates, but Messrs. E. Gouin & Co. offered to furnish the foundations up to low water mark, in one solid mass of cut stone masonry the size of the pier, at the engineer's estimates for tubes, provided they were allowed to substitute caissons: as this proposal afforded about twenty per cent. more base, in a single homogeneous mass, and at a less cost, it was gladly accepted.

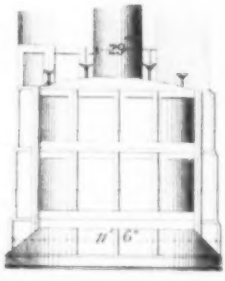
The Scorff is here in a tide-way. At extreme high tide, there was 23 feet of water and 46 feet of silt over the rock at the site of one pier, and 23 feet of water and 26 feet of soft silt and mud over the other. The surface of the rock was rough and broken, so that it was necessary to quarry it, before a good bearing could be obtained for the piers, and this had to be done at a depth of 49 and 69 feet below high water, while the action of the tides considerably complicated the precautions to be taken in carrying on the pneumatic process.

M. Gouin built for each pier a boiler plate inverted caisson, or working chamber, 39 feet 8 inches long, 11 feet 6 inches wide, and 10 feet high, the plates increasing in thickness from the bottom, and being $\frac{1}{2}$, $\frac{3}{8}$, and $\frac{5}{16}$ thick. The roof was made of $\frac{3}{8}$ plates, and slightly arched, as the full weight of the masonry was to rest upon it in the process of sinking. Its interior framing consisted of a series of curved wrought iron beams, abutting against cast iron struts, extending from side to side, to resist the pressure of the soil, and the roof was sustained by four transverse built beams, 27½ inches deep, and four longitudinal rows of 8 inch **I** beams. There was a slight batter

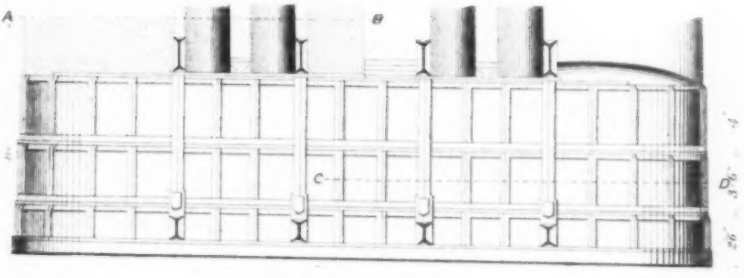
Bridge at Lorient.



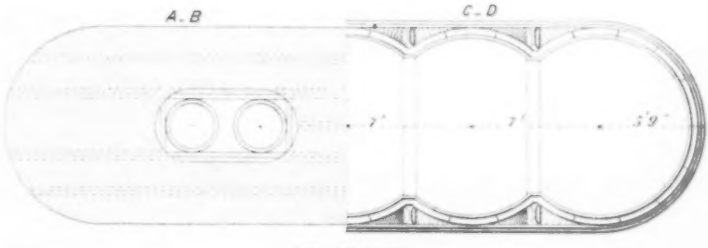
SECTION OF PIER.



CROSS SECTION THROUGH CAISSON.



LONGITUDINAL SECTION.



PLAN OF CAISSON

in the sides, which, in connection with the narrow width, proved to be a mistake, and only 4 inches retreat provided all round to offset possible irregularities in sinking, which was found quite too small.

Above the working chamber, a sheet iron enclosure or coffer-dam extended to low water, made of successive zones of $\frac{1}{4}$, $\frac{3}{16}$, and $\frac{1}{8}$ plates, rivetted on as the sinking progressed. The weight of each working chamber was 60,858 pounds, and of each surmounting coffer-dam 33,957 pounds. The general arrangement of the pier and the caisson is shown on Plate V.

As the nature of the silt and mud was such that dredges could not excavate it to advantage, and the area of foundation was much smaller than at Kehl, the materials were withdrawn in boxes through four air chimneys 27½ inches in diameter, placed in pairs, and surmounted with an equilibrium chamber 8 feet 2 inches diameter, and 9 feet 10 inches high, of which the lower part was in communication with the air tubes, and the upper part comprised the two air locks.

Operations were begun on the deepest foundation—that on the right bank. The surface of the soil was here 23 feet below high tides, or 13 feet below medium tides, but the caisson having settled by its own weight some 2 feet 8 inches into the mud, it was only at this depth that excavation in compressed air began. It was soon found that there was considerable danger of side lurches or tipping of the pier, and that the excavation had to proceed with the utmost care. The narrowness of the working chamber (11 feet 6 inches), in proportion to its length, the side batter, as well as the softness of the silt, united with the action of the tides to give it very unstable equilibrium.

In order fully to appreciate the action of the tides, it should be remembered that in order to keep the pier within the control of the suspending screws, the weight with which it is loaded should never be much greater than that necessary to overcome the friction on the sides, and the reaction of the compressed air. As the tide rises and falls, the depth of immersion and consequent displacement of the pier is constantly changing, and the equilibrium is destroyed. The caisson tends either to be lifted up by the reaction of the compressed air at the flood, or to go down suddenly at the ebb. By slightly varying the pressure, these effects were somewhat diminished, but they could not be fully overcome, as the pressure had to balance the head of water in order to prevent it from rising up inside the working chamber.

At the pier on the right bank, the soil was composed of silt with a certain consistency, so that no very serious trouble occurred, yet when the rock was reached, the pier had tilted a little towards one side, so that the four inches offset provided were lost, and the masonry had to be carried up plumb upon one face, in order to keep within the base. Another difficulty occurred, however, the coffer-dam surmounting the working chamber had buckled irregularly, so as to prevent carrying up the pier inside of the full intended size, and it even became necessary to cut away the plates at the upper end, and to work only at low water, in order to lay the upper starling.

At the pier on the left bank, although the depth to be attained was less, far greater trouble was encountered. The soil was here of soft mud, offering but slight lateral resistance, so that soon after beginning operations, the pneumatic pressure having suddenly diminished, in consequence of an accident to the blowing engine, the caisson went down all at once with a lurch, and was filled to the very roof with mud. Happily there were at the time no men in the working chamber. In going down, the caisson had tilted to the rear, and the iron skin of the coffer-dam, pressed against the masonry which filled it part way, had been torn open just above low water. The masonry at this point was yet above low water, but it was dangerous to build any more on top of it, for fear of lurching the pier still farther.

Under these circumstances, excavation was resumed in the working chamber on the up stream side, while a strong wooden platform, well strutted to the roof, was placed upon the mud inside the caisson at the lower end, so that the weight might rest upon the soil, and not upon the cutting edge. By excavating with care at the upper end, the caisson was gradually righted up, and brought back to its normal position, while the masonry was run up above the rent in the coffer-dam. The descent to the rock was then continued, not without fear and trouble, but at least without serious accident.

When the rock was reached, it was found, as expected from the borings, very irregular, there being differences of five feet in the height, within the limits of the caisson. As it was very hard, and powder could not be used within the working chamber, it would have taken a great deal of time to quarry it so as to bring the whole of the cutting edge to a proper bearing. It was, however, quarried so as to give the edge a bearing for about $\frac{4}{5}$ths of its perimeter, and for the remainder, sheet piles were driven below the edge to the rock, so as practically to prolong the working chamber, the mud

inside excavated, the rock cut in steps and cleaned off, and the caisson filled up with concrete to the roof, with all possible care.

Six months and a half were employed in founding the first pier, of which the erection of the caisson and machinery occupied three months; for the second pier, as the company were in a hurry to open the bridge, the work was pushed very actively, yet three months were consumed in putting down the foundation through the twenty-six feet of mud overlying the rock, eleven days in concreting the working chamber, and seventeen days in building the pier above the foundations.

Nothing would be more fallacious, says the engineer in charge, in the account of the works from which this description is condensed, than to base calculations upon an assumed daily rate of progress, for such works are subject to many eventualities and accidents, and the time occupied depends chiefly upon the interruptions and breakages which occur from various causes. It should, however, be remembered, that at Lorient, the irregularities of the rock, the softness of the mud, and especially the action of the tides, presented great difficulties.

Messrs. Gouin & Co. have since founded in a similar manner, upon pneumatic caissons, the piers for the bridge over the Po, at Mezzani Corti, a description of which will be found in *Engineering*, Vol II., p. 329, and Vol. III., p. 193.

The average cost per pier of pneumatic foundations have been as follows:

BRIDGE.	SYSTEM.	DIAMETER	AREA OF BASE.	HEIGHT.		AV. COST FOR ONE PIER.	
				BELOW WATER.	ABOVE WATER.		
Macon.....	2 tubes	10 ft.	157 [] ft	49 ft.	33 ft.		$16,182
Bordeaux.....	2 "	11 ft. 9 in.	217 "	52 "	28 "		21,535
Orival.....	2 "	11 ft. 9 in.	217 "	48½ "	34 "		21,945
Busswill.....	caisson	39⅓ × 13¾	540 "	49 "	15 "	$8,738	
Busswill.....	masonry					6,607	15,345
Lorient.....	caisson	39⅔ × 11½	456 "	59 "	36 "	19,530	
Lorient.....	masonry					7,834	27,364

The tubes being carried up to the bridge seat, and forming the pier, the cost of the masonry surmounting the caisson is added as above, in order to afford a correct basis of comparison.

As these works were executed at gold prices, with cheap iron and labor, and with the aid of experienced contractors, possessing complete outfits and tools required for the pneumatic process, it is probable that the cost of similar works at present prices in this country, would be from two to four times the cost abroad. Let us, for instance, take the best managed and cheapest of these bridges, that of Busswill, and apply prevailing prices here to the actual quantities in execution; the result will be as follows:

ITEMS.	QUANTITIES.	COST AT BUSSWILL.	COST IN UNITED STATES.	
			PRICE.	AMOUNT.
Caissons lowered in place.	46,100 lbs.	$2,668	11 cts.	$5,071
Iron skin for coffer-dam..	25,560 "	1,211	10 cts.	2,556
Sinking foundation	49 feet	1,968	$1,20	5,880
Hammer-dressed masonry below water.....	706 cub. yds.	4,198	$16	11,296
Cut stone masonry above water	242 " "	2,409	$25	6,050
Totals.		$12,454		$30,853
To this must be added a proportion of the general expenses, cost of scaffoldings, use of tools, &c.		2,891		7,200
Totals.		$15,345		$38,053

There being five foundations to put in at Busswill, the proportion is arrived at as follows:

	AT BUSSWILL.		IN UNITED STATES.	
	WHOLE COST.	ONE-FIFTH.	WHOLE COST.	ONE-FIFTH.
⅓th cost of temp. bridge...	$1,820	$364	$3,000	$600
⅓th " " scaffoldings...	2,810	562	5,000	1,000
⅓th " " use of tools...	8,626	1,725	25,000	5,000
⅓th " " temp. build'gs.	1,200	240	3,000	600
Totals.....	$14,456	$2,891	$36,000	$7,200

Up to a pressure of 1 or 1½ atmospheres, corresponding to a depth of 33 to 49 feet below water, although the workmen must be selected with special reference to their temperaments, and ability to resist compressed air, no serious ill effects generally result to their health, beyond severe pains and lassitude upon emerging, and occasional deafness. Beyond these depths, however, it may be necessary, as was done at Kehl, to establish an hospital at the works, and to have a physician in attendance in order to relieve cases of asphyxia, and treat the numerous instances of illness which arise.

It will thus be seen that the pneumatic is anything but a cheap process, but that whenever it becomes necessary to resort to it, the stability of the pier will be greater if founded on caissons than on tubes, while the cost of a given area of base will be less. Beyond the very complete command which it gives over the uniformity of the undermining and the removal of obstructions, and also probably the effects of the air escaping from under the lower edges, in diminishing the friction of the soil, it is a positive detriment. It counteracts a large proportion of the load in sinking, it causes serious accidents in case of breakages in the blowing machinery, air-pipes, joints or tubes; it compels the use of special workmen at high wages, and endangers their health; and it does not always lead to economy of time, particularly when special machinery has to be constructed to employ it. Wherever rock is not very deep below the surface, or the circumstances of location admit of it, the present high prices of iron and labor, and the want of adequate plant for the pneumatic process in this country, will probably make it cheaper and more

judicious to resort to other methods, such as bottomless caissons, sheet pile coffer-dams, or even wooden pile foundations.

Mr. McAlpine has recently so ably pointed out in this *Journal*, the danger, under certain circumstances, of trusting to piles sustained exclusively by the friction of the soil against their sides, that engineers will generally agree that it is unsafe to resort to them in locations subject to deep scour. Yet, as in consequence of their cheapness, and the rapidity with which they can be put down, pile foundations will always offer strong temptations to the engineer, it may be deemed important to inquire under what circumstances they may be safe in our great western rivers, which flow over beds of sand.

The chief danger to the stability of piers, aside from shocks from ice or other floating objects, arises from possible unequal scour upon their opposite sides, thus undermining on one side, while the whole thrust of a bank of saturated sand is exerted on the other. In a recent instance, at one of the bridges now building in this country, a sudden freshet scoured out twenty-five feet deeper on one side of a bottomless caisson in process of sinking than on the other, and upset and destroyed the works, and the belief is entertained that had the foundation been put down with tubes, columns less than twelve or fifteen feet in diameter, would not have been safe against this action.

Unless turned by obstacles, the Mississippi and Missouri rivers, in sweeping from side to side of their valleys, make a succession of pairs of reversed curves, generally abraded by the current to the same radius, with straight reaches between them. The channel crosses the bed of the river diagonally between the curves, impinges against the shore, and is reflected towards the opposite bank. The straight reaches occur at the foot of the lower curve, where the resulting angle of reflection assumes a direction nearly parallel with the shore. The changes which take place in the shores on both sides, present a series of interlocking, SS, proceeding down stream, the advancing eddy of the one filling up the bends excavated by the preceding S, and its current vein scouring out former sand bars; so that in a cycle of years, no obstacle intervening, the channel returns to its former bed.

As the building of a bridge across these streams, will generally involve the mainteuance permanently of the chaunel through certain spans, the engineer will be led to locate the crossing just below

one of these curves, so that by making use of the impinging force of the current, the protection of one shore against further abrasion, shall give the command of both. Now the scour in these rivers during a flood is not uniform across their entire bed, but attains its greatest limit in the main high water channel, and decreases towards the convex shore, while, in consequence of the centrifugal action of the water towards one bank, and consequent slack current on the opposite shore, some points on the inside of the curve actually silt up during a flood. If the shore on the concave bank of the river above the bridge site be protected, so that no further advance in this direction can take place, it may be both safe and proper, even in the Missouri river, to put in pile foundations under some of the piers on the convex bank.

In the upper Mississippi, which has a far more stable *régime* than the lower river or the Missouri, it will probably be safe to found even the channel piers upon piles, provided they are properly driven to the rock, and if possible into it. They will then become columns of support instead of piles, the sand merely acting as braces to keep them in place. It will be necessary, however, to tie their heads firmly together, to protect them heavily with rip rap, and to keep it in repair, as otherwise, in case of partial scour, motion might ensue, and the foundation merely become a hinge for the pier to turn on.

In the Missouri, when the crossing is located just below a curve, a few foundations on the convex bank will be safe on piles; those in the channel, and *all* the foundations, if the crossing be upon a straight reach, must be carried down to rock, or below any possible scour, and must have sufficient base and weight to resist the thrusts to which they may be exposed. It will generally be found, moreover, that the bed rock is abraded deeper, and the scour greater on a straight reach than around or near a curve, and the channel more unstable. Should it be desired to confine navigation to certain spans, the shores must be protected above the bridge site, so that the angle of reflection, and consequent direction of the channel shall not change.

This sketch cannot better be closed than by translating the conclusion of a paper upon foundations, read before the Institution of French Civil Engineers, by M. Croisette Desnoyer, the chief engineer of the bridge at Lorient, which seems to resume very well the opinion of European engineers on this subject.

"The use of compressed air admits of penetration to very great depths in soft and permeable soils; it therefore affords a means of going down to rock, of clearing it off and leveling it, in locations where it would otherwise be impossible to reach it. It gives, consequently, a solid base for the foundations, and enables us to do the work with all necessary care, while it can be prosecuted almost without reference to the stage of water, so that work can be carried on almost at all seasons.

"But, as against these advantages, it presents great inconveniences. It may, at great depths, injure the health of the workmen. It threatens numerous chances of accidents. It compels long preparations, and finally, it is very expensive. This last circumstance, leads to reducing as much as possible the area of the foundations, and consequently diminishes their stability.

"Compressed air may be employed either in tubes or caissons. The tubes are more easily handled, and present fewer chances of accident in the sinking, but they are generally of small size, give but small bearings, and are only suitable for beam bridges. If they are of large diameter, they cost more than a caisson; (thus we have seen that at Lorient, a caisson was substituted without increased cost, for two tubes, 14 feet 9 inches in diameter), and they do not, like caissons, furnish a single homogeneous base. It is exclusively in caissons, therefore, that it is proper to employ compressed air for masonry piers, or for abutments founded upon soils likely to exert considerable side thrusts. In the latter case it will be sufficient to employ two parallel caissons, placed longitudinally. It would be well to adopt this arrangement, even for the abutments of iron bridges when founded upon oozy beds.

"Compressed air should evidently not be used for depths less than 10 metres ($32\frac{8}{10}$ feet), for up to this point, it would certainly be cheaper to put in the foundations, even in the middle of a river, either by the ordinary methods of excavation, or with submerged concrete. In still water, the ordinary methods of excavation may be carried to far greater depths than 10 metres in impermeable soils. Even when this last condition is not fulfilled, foundations may be put in upon wooden piles, provided it is found practicable first to test the soil by loading. In all these cases, the employment of compressed air would occasion greater expense, and should be avoided. It is best, therefore, to reserve this process, 1° for river foundations more than 10 metres in depth, 2° for very deep

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foundations, in still water, in permeable soils where it is not possible to employ piles, or where, in consequence of the great importance of the work, this last method, even under good conditions, is not deemed sufficient.

"In any case, where the soil does not offer lateral support, it seems to us almost indispensable to increase the width of the caissons, by providing wide offsets at the base of the piers. The danger of lurches in the descent would thus be diminished, and the stability of the foundation much increased.

"Without ignoring any of the advantages of this powerful means of action, we therefore think that its employment should not be carried too far, and that, both on account of its great cost and of the chances of accidents which it presents, it is best to reserve it for difficult circumstances, where it would be nearly impossible to reach a good solution by the other processes."

THE ECONOMICAL CONSTRUCTION OF BEAM TRUSSES.

By G. S. Morrison, C. E.

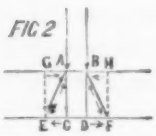
The problem of bridging the great western rivers, which has of late given so much interest to the subject of deep foundations, demands that equal attention be paid to the study of superstructures. The necessary expense of deep foundations calls for the introduction of much larger spans than have hitherto been found economical, and at the same time requires these long spans to be built with the least possible waste of material.

The form of truss in most common use is that known as the beam truss, the top and bottom of which are formed of two parallel chords, in distinction to parabolic trusses, in which the principle of the arch is used, and suspension trusses, in which a flexible beam is stiffened by a combination of bracing beneath it. The following pages will be confined to the discussion of beam trusses, and to deducing from a similar examination of the strains which act in them the most advantageous arrangement of the several parts. This will necessarily include a review of the advantages of making the same truss continuous over several spans, a practice in very general use among European engineers, and which leads to a saving sometimes as high as 25 per cent. in the intermediate spans of a bridge.

If a weight were placed upon a beam, and there were no lateral

adhesion between the successive parts of that beam, the weight would cut its way through by forcing down the portion under it, as shown in Fig. 1.

Lateral adhesion distributes the effect of the weight beyond the part of the beam directly under it. In Fig. 2, let A and B represent two adjacent points on which the weight exerts forces in the direction indicated by the arrows. If these forces were not disturbed, they would act along the lines AC and BD, but being diverted by the adhesion of the particles of the beam, they extend into the adjacent parts and act also along inclined lines represented by AE and BF, causing compression in these lines. The reaction of the material in these compressed lines will exert forces as indicated by the arrows; decomposing these reacting forces at the points A and B, into their horizontal and vertical elements, the vertical elements alone are balanced by the weight, and the horizontal elements tend to force the points A and B together, while at the lower side of the beam, the horizontal elements tend to draw the points E and F apart. The effect of the weight is, therefore, to shorten the fibres above and lengthen those below, thus changing their relative lengths and bending the beam, as shown in Fig. 3.



Hence, it appears that a beam under the influence of weight, which may be either its own or a superimposed weight, is subjected to strains of two kinds:

1. A *shearing strain*, tending to cut the beam by causing one part to slide upon an adjacent part.

2. A *bending strain*, bending the beam by shortening the fibres above, and lengthening those below.

The economical construction of beam trusses lies in selecting the best methods of resisting these strains.

When a beam is bent, the outside fibres undergo a greater change of length than the intermediate ones, and consequently the intermediate fibres are less strained than the extreme ones. If all the material were concentrated at the top and bottom, the whole would be equally strained, and all act at the greatest advantage. Hence, in a beam truss, the material should be thrown into the top and bottom, leaving only enough between to resist the shearing strains. The

truss will consist of an upper and lower chord, whose function is to confine within safe limits the bending strain; and an intermediate web, whose function is to resist the shearing strain.

The shearing strains and construction of the web will be considered first, and an examination of the relations existing between the two kinds of strains and the methods of reducing the strain upon the chords will follow.

I.—Shearing Strains.

When a part of a beam is forced down between the adjacent parts; on one side, a surface on the right slides downward upon a surface on its left, and on the other a surface on the left slides downward on a surface to the right, or, relative position only being considered, a surface on the right slides upward on a surface to the left. These two motions being opposite, the strains which cause them should be represented with opposite signs. That shearing strain which tends to move the right hand surface downwards upon the left, will be considered positive, the reverse, negative.

When a beam, resting upon two supports, is uniformly loaded throughout, the whole weight is divided equally between the two supports, each bearing the weight upon the adjacent half of the beam. The shearing strain at the left hand end of the beam is equal to half the whole load, and at the right end to minus the same quantity; the intensity decreasing uniformly from the ends to the centre, where it vanishes. This will be apparent by considering the force with which the sections marked A are driven down, in the three different cases represented by Figs. 4, 5 and 6.

If w represents the weight upon each unit of length, the shearing strain at a point at the distance x to the right of the centre of the beam, is $-wx$. In Fig. 7, let C be the centre of the beam, AB, uniformly loaded. The shearing strains at every point will be the ordinates of the line whose equation is

FIG. 4

$$y = -wx.$$

C being the orgin. Making $\text{AD} = -\text{BE} = \frac{wl}{2}$, l being the length of the beam, DE will be this line.

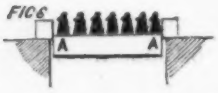
The dotted line de gives the shearing strain in the same beam when uniformly loaded with a weight equal to $\frac{1}{2}\ w$.

When a beam is but partially loaded, as in Fig. 8, (the beam itself

being supposed without weight), the weight is divided between the two supports in the inverse ratio of their distances from the centre of the load. The support A bearing the two weights next to it and $\frac{5}{7}$ths of the third, and the support B being the fourth weight, and $\frac{2}{7}$ths of the third. The shearing strains vanish at the point which thus divides the part of the load borne by one support from that borne by the other, and increase uniformly in intensity from that point to each end of the loaded portion; but the shearing strain is the same throughout the unloaded part of the beam, as it attains its full intensity at the end of the load, and there is no further weight to alter it. The strains will be given by the ordinates of a broken line, parallel to the line at strain for a fully loaded beam throughout the loaded portion, and parallel to the axis of abscissas through the unloaded part.

FIG 5.

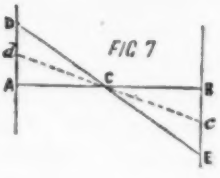
FIG 6



If l' denotes the length of the loaded portion, the weight borne by the loaded support is

$$\frac{l'\,w\,(l-\frac{l'}{2})}{l} = l'\,w - \frac{l'^2 w}{2l}$$

FIG 7



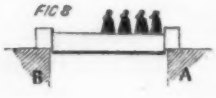
and by the unloaded

$$\frac{l'\,w \times \frac{l'}{2}}{l} = \frac{l'^2 w}{2l}$$

Through the loaded part of the beam the shearing strains are the ordinates of the linear equation

$$y = \mp \frac{l'^2 w}{2l}$$

FIG 8



the positive sign being used when the weight is next to the right hand support, and through the loaded portion by the ordinates of the lineal equation.

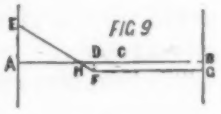
$$y = \mp\left(l'\,w - \frac{l'^2 w}{2l}\right) - \left(x \mp \tfrac{1}{2}\,l\right)w = \mp\frac{(l-l')^2 w}{2l} - wx$$

the positive signs being used when the weight is next to the left hand abutment.

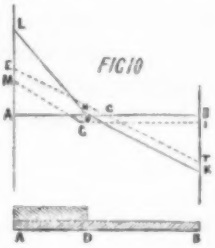
In Fig. 9 the beam is supposed to be loaded from A to D, and the broken line AFG is the line of strain.

When a beam is entirely loaded, but more heavily in one part

than another, the only practical case of a partial load, it may be regarded as uniformly loaded with a weight equal to that on the more lightly loaded portion, while a part of the beam bears also an additional load. The shearing strain produced by the united load will be at every point the sum of the strains produced by the two loads acting separately.



In Fig. 10, the beam AB is loaded uniformly with a weight equal to w for each unit of length, the part AD bearing an additional weight equal to w'. The strains caused by the uniform load are given by the line EF, and those caused by the partial load acting alone, by the broken line, MGI, while those resulting from the combined load are given by LHK, the ordinates LHK being at each point equal to the sum of the ordinates of the other two lines.



The equation of LH is:

$$y = -\frac{(l-l')^2 w'}{2l} - (w+w')\,x$$

and that of HK

$$y = -\frac{l'^2\, w'}{2l} - wx$$

HK is parallel to EI, and LH to a line passing through C, and corresponding to a uniform load equal $w + w'$. For the point of intersection H

$$x = l' - \frac{l}{2} \qquad y = \frac{l^2\, w - l'^2\, w}{2l} - l'\, w$$

To consider the effect of a moving load, let AB, Plate, Fig. 11, represent a beam upon which a load advances from A towards B. The shearing strains will then be indicated as follows:

Beam empty, by line			DE.		
Moving load covering			Aa,	by line	$a''\ a'\ a'''$
"	"	"	Ab,	"	$b''\ b'\ b'''$
"	"	"	Ac,	"	$c''\ c'\ c'''$
"	"	"	Ad,	"	$d''\ d'\ d'''$
"	"	"	Ae,	"	$e''\ e'\ e'''$
"	"	"	Af,	"	$f''\ f'\ f'''$
"	"	"	Ag,	"	$g''\ g'\ g'''$
"	"	"	Ah,	"	$h''\ h'\ h'''$
"	"	"	Ai,	"	$i''\ i'\ i'''$
"	"	"	*whole beam*	"	FG.

The points of intersection a' b' c' &c., lie upon a regular curve, DSG. As the load leaves the beam from the end, B, a similar series of changes takes place, the signs, however, being reversed, and the strains will be given by an arrangement of lines bounded by the curve, FS′E.

The bounding curves, DSG, and FS′E, give the limits of shearing strains under the action of a moving load. Between A and S it is always positive, and between S′ and B always negative, while between S and S′ it may be either, the point dividing the load borne by one support from that borne by the other shifting back and forth between these two points as the load advances.

The most intense strain at any point occurs when the load extends from that point to the more distant abutment; and the least intense strain, except between S and S′, where the strains at times vanish, when the load extends from the given point to the nearer support.

In Fig. 10 we have for the ordinate of the point H:

$$y = \frac{l^2 w - l'^2 w}{2l} - l' w$$

which, if l' be made a variable, becomes the equation of the curve, DSG, and shows that curve to be a parabola. For the point S

$$y = \frac{l^2 w - l'^2 w'}{2l} - l' w = o$$

$$l' = \frac{\sqrt{w(w+w')} - w}{w'} l$$

The distance from S to the centre of the beam is—

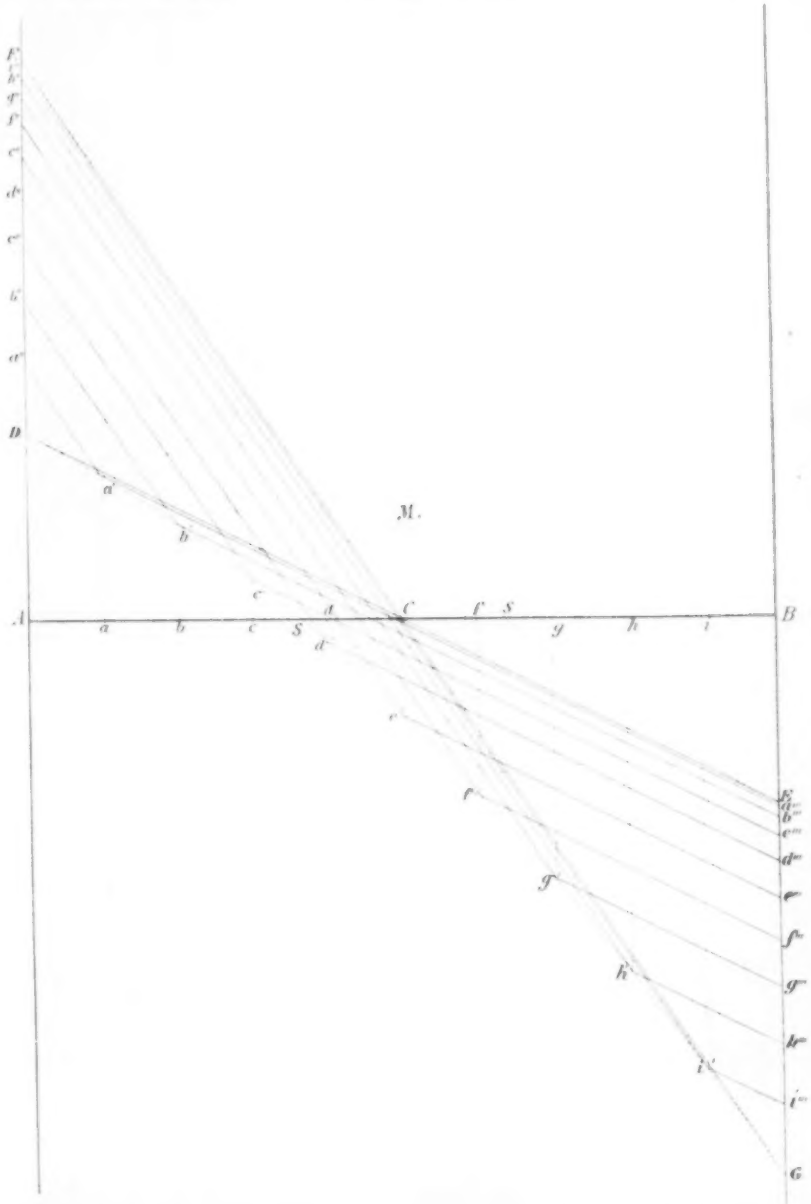
$$\tfrac{1}{2} l - l' = l \left(\tfrac{1}{2} - \frac{\sqrt{w(w+w')} - w}{w'} \right)$$

and from the centre of the beam to S′ is the same At the centre of the beam, l' must be made equal to $\frac{1}{2} l$, which gives—

$$y = Ce' = -\frac{l w'}{8}$$

or the greatest possible shearing strain at the centre of the bridge is equal to one-eighth the total moving load. The strain at any other point may be easily found by simply constructing the curves. The members of the web should be proportioned accordingly.

A similar investigation might be made into the effects of a load of three different intensities; but as the strains would everywhere be less under the action of such a moving load, than under the


M.
A
B
a
b
c
d
C
f
S
g
h
i
D
G

action of a load of two different intensities corresponding to the greatest and least of the three, such an investigation is unnecessary.

(To be continued.)

INTER-OCEANIC COMMUNICATION BETWEEN THE ATLANTIC AND PACIFIC.

By D. S. Howard, C. E.

THE NICARAGUA ROUTE.

The natural advantages of this route were so apparent that every one wished to secure them to himself and his associates. Its early history shows that the first notice of it created a bitter controversy, which was kept up until another route, without any natural advantages, had been, by the sacrifice of an extravagant amount of money and human life, successfully established.

Nothing can flourish between belligerants. The victory is liable to be won by the party more skilled in strategy than the science of improving rivers and harbors, which was the case in this instance. But so much controversy as this route created, naturally raised the value of it in the eyes of the people of Nicaragua, so that now, after it has happened to fall into right hands for successful management, the government of Nicaragua increases their requirements for the privilege of improving their country, and lessen the exclusive privileges to be granted as equivalent. Thus the matter now stands.

The present Transit Company, with Mr. W. H. Webb as President, with abundant capital to do anything that may be advisable to be done, only ask a charter that will guard them against any vicious competition, such as the great natural advantages of this route might elicit.

The plan of improvement which the Company have adopted, has been so far tested already, that its success scarcely admits of a doubt.

They propose, first, to divert water enough from the Colorado outlet, which leaves the San Juan River twenty miles from the Carribean coast at Greytown.

This they will do by dredging at and below the junction of the Colorado. The declivity in the bed of the San Juan, below the junction, being about one and a-half feet per mile, renders it unnecessary to make the excavation more than four or five miles below

the junction with the Colorado. By making this about eight feet deep, in the lowest water, and about two hundred yards wide,—putting the material taken out into the Colorado,—will turn water enough down the lower San Juan to open the harbor at Greytown, and afford sufficient water for steamers drawing three or four feet at all seasons.

For this purpose, the Company have already provided a powerful dredging machine, capable of raising over three thousand (3,000) cubic yards per day of ten hours. This machine is provided with long spouts to run off the excavated material with water, for the purpose of dispensing with lighters, the expense and delay of towing to a place of deposit, &c., as much as possible, which was done with great success by a similar machine in the construction of the Corpus Christi Ship Channel, in Texas, in 1857–8. The same thing is now being done in the construction of the Suez Canal, mentioned in the June number of this *Journal*, page 378, by Mons. Lavalley, with the most gratifying results. This gentleman claims the above plan as his special invention. I do not wish to controvert this fact, presuming the idea was original with him, but, in justice to myself, I must say, that I made use of the same device in the construction of the Corpus Christi Ship Channel, as early as 1857, and successfully completed the work without the use of a lighter, except to hold up the outer end of the spouts. The idea was, then, original with me, whoever might have used it previously. I mention this fact, not to detract from the world-wide renown of Mons. Lavalley as an eminent engineer, but to claim the greater credit of preceding, in this instance, so successful an originator.

One great advantage of this route is its measurable availability, to begin with. Throughout the wet season, about half of the year, it is, in its natural state, a better route than any yet in use. It moreover affords important facilities for further improvement, so that every dollar properly expended upon it adds immediately to its value.

It is estimated that when three hundred thousand dollars shall have been expended on the the plans adopted by Mr. Webb, that this will successfully compete with any other route that can be made, short of a ship canal of the largest class.

These plans are so adapted to the natural advantages of this route, that improvement may go on until a first-class ship canal shall have been completed, without abandoning anything, at any time, as useless, that may have been done previously, so that, in the meantime, the navigation will have been improved by every

days' labor, and every dollar expended during the progress of the work, rendering loss of interest on capital actually expended, in case of any unforeseen delay, impossible at any time.

The great objection raised to investing money in the improvement of this river, is stated to be the "movable sands in the bottom." This sand can be excavated and transferred from the San Juan to the Colorado, at less cost than any other material. It is also more readily removed from the channel, by a judicious application of currents for scouring, than the more faultless materials. There has been so much time, talent, and money heretofore expended on rivers of this character, having a limited supply of water, with no resource for adding to or increasing the amount, with little or no success, that the improvement of this river is considered almost impossible by those who do not happen to know and appreciate the exceptional condition here existing, which is an abundant supply of water at all seasons, so situated as to be readily controlled.

The Rapids, on the upper river, may be improved for boats drawing four feet water, without the obstructions of locks and dams, by grading a sufficient channel to an easy ascent, adapted to the requirements of the boats to be used. This may be done at a trifling expense, compared with that of dams and locks.

With the Rapids and lower river and harbor improved at Greytown, the route is complete to within twelve miles of the Pacific. This part the Company propose to improve, by the construction of a railroad, from Virgin Bay, on the Lake, to Del Sur, on the Pacific.

From the increase of inter-oceanic trade, since the completion of the Panama Railroad, it is reasonable to predict the early necessity of a ship canal, in addition to these improvements. The feasibility of such a work has been made evident from a very exact survey by O. W. Childs, one of the most accurate and skilful engineers of his time. To show that his estimate was ample to provide for the full completion of the work, I will state that, during the six years he was Chief Engineer of the State of New York, he was never known to under-estimate any work in his charge.

His report on the Nicaragua Ship Canal was submitted to Cols. Albert and Turnbull, of the Topographical Bureau at Washington, who pronounced it ample for the purpose mentioned, and no person had attempted to criticise his items or question his amounts, until Rear Admiral Davis made his report on Inter-oceanic Communication, who seems to question it in a way which conveys the idea that a much larger sum than is named in the estimate will be

required. To make this appear, he mentions that "costly improvements, possessing the character of artificial harbors, will be necessary at the two points of departure from the Lake," &c. It is well known by every person that has been through the route, with any degree of discrimination in such matters, that no such structures are necessary.

The western departure from the Lake is perfectly protected by the form of the shore and Ometepe Island. The eastern departure is the outlet of the Lake, and is as perfect a harbor as can be made, well known to be perfectly safe for the native bungoes—large open boats navigating the Lake and river from Granada to Greytown at all seasons of the year.

Mr. Davis' report bears the marks of a questionable design, by some person or persons, on whom he depended too much for information concerning this route, who, probably, in the first instance, suggested the propriety of such a report to some influential member of Congress, for some private speculative purpose. I do not mean to cast any unworthy reflections upon Mr. Davis, who so worthily received the compliment from Congress of being selected to make this report; but the indications of some special design, in the manner of treating the description of this route in connection with others, are so plain to any person at all conversant with it, that it would be inconsistent with a proper regard for the true character and condition of the subject, to pass it unnoticed.

No country in the world can boast of a more salubrious, healthful climate, particularly along this route. There is no stagnant water, the river having a uniform descent of about one and a half feet per mile, between the Rapids, except seventeen miles immediately below the lower Rapids, which partakes of the nature of a deep, pure lake, rendering any accumulation of vegetable mud anywhere in the river-bed impossible, while all that may be deposited on the banks by freshets, is dissipated by the extraordinarily luxuriant growth of vegetation.

The delightful scenery along this route is not surpassed in any other uncultivated country. The luxuriant vegetation of various species of vines, and numerous varieties of parasites cover every tree in the first stages of decay, so that nothing is presented to the observer but the liveliest shades of living tropical vegetation on every side.

Lyons' Falls, N. Y., July 9th, 1868.

Mechanics, Physics, and Chemistry.

LECTURE-NOTES ON PHYSICS.

By Prof. Alfred M. Mayer, Ph.D.

(Continued from page 53.)

The Theory of Energy considers its Conservation, its Transformation and its Dissipation.

The *Conservation of Energy.*—The total amount of energy in the universe, or in any limited system which does not receive energy from without, or part with it to external matter, is invariable. Energy is, in other words, as indestructible as matter, and is neither created nor destroyed, but merely changes its form.

The *Transformation of Energy.*—By an extended induction, we find that any one form of energy may be transformed, wholly or partially, to an equivalent amount in another form. These transformations are, however, subject to limitations contained in the principle of

The *Dissipation of Energy.*—"No known natural process is exactly reversible, and whenever an attempt is made to transform or retransform energy by an imperfect process, part of the energy is necessarily transformed into heat and dissipated, so as to be incapable of further useful transformation. It therefore follows that as energy is constantly in a state of transformation, there is a constant degradation of energy to the final unavailable form of uniformly diffused heat; and this will go on as long as transformations occur, until the whole energy of the universe has taken this final form." See *N. Brit. Rev.*, May, 1864.

"There is consequently," says Prof. Thomson, "so far as we understand the present condition of the universe, a tendency towards a state in which all physical energy will be in the state of heat, and that heat so diffused that all matter will be at the same temperature; so that there will be an end of all physical phenomena."

Vast as this speculation may seem, it appears to be soundly based on experimental data, and to represent truly the present condition of the universe, so far as we know it. See Prof. Thomson "*On a Universal Tendency in Nature to the Dissipation of Mechanical Energy.*"—Proc. R. S. Edinb. and Phil. Mag., 1852.

The energy of a *moving* body is the work which it is capable of performing against a resistance before being brought to rest, and is equal to the force which must act on the body to move it from a state of rest to the given velocity. This force is measured by the product of the mass of the body into the height from which it must fall in order to acquire the given velocity; which is expressed thus:

$$\text{Energy} = \frac{M V^2}{2 g}$$

g representing as usual, the velocity acquired by a body at the end of the first second of its fall.

Energy may be of two kinds (1), *Kinetic energy*, or energy of motion, and (2) *Potential energy*, or energy of position or of condition. Thus, the energy of a ball shot vertically upward, is entirely kinetic at the moment of its discharge, while its energy is all potential, or one of position, when it has reached the summit of its flight and begins to descend. It is evident that the ball in descending, will gradually lose potential energy and gain kinetic energy (the sum of the two energies always remaining constant), and when it has reached the level from which it was discharged upward, its energy is again all kinetic, and equal to what it was when it began its upward flight. An oscillating pendulum is an instance where the energy is alternately kinetic and potential.

All the various forms of energy may be brought under two classes.

I. *Visible Energy*, or energy of visible motions and positions.

II. *Molecular Energy.*

Under class I. we have

A. Visible kinetic energy.

B. Potential energy of visible arrangement, as for examples, a head of water; a coiled spring; a raised weight.

Under class II.

C. The energy of electricity in motion.

D. The energy of radiant heat and light.

E. The kinetic energy of absorbed heat.

F. Molecular potential energy.

G. Potential energy caused by electrical separation.

H. Potential energy caused by chemical separation.

Now with regard to these various forms of energy, the principle of the conservation of energy asserts that for a body left to itself, or for the entire material universe, we must have

A+B+C+D+&c.,=a constant quantity.

On the other hand, the various terms of the left hand member of this equation must be considered as variable quantities, subject, however, to the above limitation, but capable of being transformed into one another according to certain laws.

Laws of the transmutations of energy.—The following are among the most important cases of transmutation of these energies into one another.

A into B, when a weight is projected upwards; into C, when a conductor revolves between the poles of a magnet. A is not transmuted directly into D; it is into E, F and G. A is not directly converted into H.

B can be converted into A, and through it into other forms of energy.

C can be transmuted into A, into E, into F, and into H.

D can be transmuted into E, into F, and into H.

E and F is converted into A and into B, in the action of any heat-engine; into C, into D; into G when tourmaliñes are heated; and into H.

G can be converted into A and into C.

H can be transmuted into C; into E, into F, and into G. (See Elementary Treatise on Heat, by Balfour Stewart, Oxford, 1866.)

Sources of Energy.—The energy available for the production of mechanical work is almost entirely potential, and consists of

Potential forms of Energy.

1. Energy of Fuel.
2. Energy of Food.
3. Energy of Ordinary Water-Power.
4. Energy of Tidal Water-Power.
5. Energy of Chemical separation implied in native sulphur, native metals, free oxygen, &c.

Of Kinetic forms of Energy.

6. Energy of Winds and Ocean Currents.
7. Energy of Direct Rays of the Sun.
8. Energy of Volcanoes, Hot Springs and Internal Heat of the Earth.

"The immediate sources of these supplies of energy are four:—

I. Primordial Potential Energy of Chemical Affinity, which probably still exists in native metals, native sulphur, &c., but whose amount, at all events near the *surface* of the earth, is now very small.

II. Solar Radiation. III. The Earth's rotation about its axis.

IV. The Internal Heat of the Earth.

Thus, as regards (1) our supplies of fuel for heat-engines are, as was long ago remarked by Herschel and Stephenson, mainly due to solar radiation. Our coal is merely the result of transformation in vegetables, of solar energy into potential energy of chemical affinity. So, on a small scale, are diamond, amber and other combustible products of primeval vegetation. As Prof. Thomson remarks, wood fires give us heat and light which have been got from the sun a few years ago. Our coal fires and gas lamps bring out, for our present comfort, heat and light of a primeval sun, which have lain dormant as a potential energy, beneath seas and mountains for countless ages.

Though (II) thus accounts for the greater part of our store of energy, (I) must also be admitted, though to a very subordinate place.

As to (2), the food of all animals is vegetable or animal, and therefore ultimately vegetable. This energy, then, depends almost entirely on (II). This, also, was stated long ago by Herschel.

Ordinary water-power (3) is the result of evaporation, the diffusion and convection of vapor, and its subsequent condensation at a higher level. It also is mainly due to (II).

Tidal water-power (4), although not yet much used, is capable, if properly applied, of giving valuable supplies of energy. As the water is lifted by the attraction of the sun and moon, it may be secured by proper contrivances at its higher level, and then becomes an available supply of energy when the tide has fallen again. Any such supply is, however, abstracted from the energy of the earth's rotation (III). This was recognized by Kant; Mayer also and J. Thomson showed that the ebb and flow of the tides being due to the earth's revolving on her axis under the moon's attraction, the energy of the tides is really taken from the energy of the earth's revolution; part of which is thus ultimately dissipated in the heat of friction caused by the tides. The general tendency of tides on the surface of a planet is to retard its rotation till it turns always the same face to the tide-producing body; and it is probable that the remarkable fact that satellites generally turn the same face to

their primary, is to be accounted for by tides produced by the primary in the satellite while it was yet in a molten state.

Winds and ocean currents (6), both employed in navigation, and the former in driving machinery, are, like (3), direct transformations of solar radiation (II).

As to (8), which is due to (IV), no application to useful mechanical purposes has yet been attempted.

We must next very briefly consider the origin of these causes, with the exception of (I), which is of course primary. Laplace, Mayer and Helmholtz come to our assistance, and suggest as the initial form of the energy of the universe, the potential energy of gravitation of matter irregularly diffused through infinite space. By simple calculations it is easy to see that, if the matter in the solar system had been originally spread through a space enclosing the orbit of Neptune, the falling together of its parts into separate agglomerations, such as the sun and planets, would far more than account for all the energy they now possess in the forms of heat and orbital and axial revolutions.

The sun still retains so much potential energy among its parts, that the mere contraction by cooling must be sufficient (on account of the diminution of potential energy) to maintain the present rate of radiation for ages to come. Moreover, the capacity of the sun's mass for heat, on account especially, of the enormous pressure to which it is exposed, is so great that (at the least and most favorable assumption) from 7,000 to 8,000 years must elapse, at the present rate of expenditure, before the temperature of the whole is lowered one degree centigrade, although the amount of solar heat received by the earth in one year is so enormous that it would liquify a layer of ice 100 feet thick, covering the whole surface of the earth, and if we bear in mind that the solar heat which reaches the earth in any time is only $\frac{1}{2300000000}$ of the heat which leaves the sun, we may obtain some idea of the immense heating power of the radiation from our luminary.*

It thus appears that if we except tidal-power, the sun's rays are the ultimate source of the available forms of energy with which we are surrounded.†

* If the entire solar radiation were employed in dissolving a layer of ice, enclosing the sun, it would dissolve a stratum 10½ miles thick in a day.

† The sketch we here give of the *Sources of Energy*, is taken almost entirely from an article on "Energy," in the N. Brit. Rev., May, 1864.

We see, from the above exposition, that "Philosophers have extended their ideas of quantity from matter to energy, and thus has arisen the new science of *Energetics*, or the quantitative study of the transformations of energy (as chemistry is the quantitative study of the transformations of matter), comprehending and uniting all the different branches of physical science."

Efficiency of Heat-Engines.—After Joule had determined the mechanical equivalent of heat, engineers had the means of testing the actual efficiency of heat-engines.

If the number of thermal units produced by the combustion of one pound of a given kind of fuel, be multiplied by Joule's unit, 772 foot-pounds, the result is the *total heat of combustion* of the given fuel expressed in foot-pounds. This quantity ranges between 5,000,000 and 12,000,000 foot-pounds. But in the best existing steam-engines, it is found that on an average only about $\frac{1}{8}$ of the mechanical value of the heat produced by the fuel burning in the furnace, is obtained as useful mechanical effect, the remaining $\frac{7}{8}$ being wholly lost.

To understand the cause of this great loss, it is to be remembered that in every heat-engine the heat of the expansible fluid—which is the medium by which the heat of the fuel is transformed into the motion of the engine—disappears *as heat* by the exact equivalent, expressed in Joule's units, of the motion produced. Therefore the greater the fall in heat in the vapor, which, in expanding, cools and gives up its heat as motion, so will be the efficacy of the engine. Just as in a head of water, where the greater the difference between the higher and lower level, the greater the power obtained. But in the steam-engine we are obliged to obtain our power from the fall in temperature of the steam, which takes place in its expansion, so that in a steam-engine the power obtained is measured by the difference of temperature between the boiler and condenser, and *not* by the difference between the temperature of the furnace and condenser. Now, in the furnace the temperature is about 3,000 degrees above that of the atmosphere, while the temperature of the boiler is only about 200 degrees in excess of that of the condenser; therefore it is evident that the larger fall in temperature taking place between the furnace and the steam, the heat is lost or at least not utilized.

In a *perfect engine* the steam would enter the cylinder at the temperature of the furnace, and expand down until it had given up all its heat as motion to the piston, and would then enter the condenser

at the temperature of the atmosphere; indeed, such an engine would require no condenser, for the steam would condense itself as the heat disappeared in its transmutation into motion.

We will conclude this sketch on the subject of Energy, with a concise statement in reference to the efficiency of heat-engines, taken from Prof. Rankine; referring the reader who desires further information on this important and interesting subject to the works given below.

"The total heat produced in the furnace is expended, in any given engine, in producing the following effects, whose sum is equal to the heat so expended:—

1. The *waste heat of the furnace*, being from 0·1 to 0·6 of the total heat, according to the construction of the furnace and the skill with which the combustion is regulated.

2. The *necessarily-rejected heat of the engine*, being the excess of the whole heat communicated to the working fluid by each pound of fuel burned, above the portion of that heat which permanently disappears, being replaced by mechanical energy.

3. The *heat wasted by the engine*, whether by conduction or by non-fulfilment of the conditions of maximum efficiency.

4. The *useless work of the engine*, employed in overcoming friction and other prejudicial resistances.

5. The *useful work*. The efficiency of a heat-engine is improved by diminishing as far as possible, the first four of those effects, so as to increase the fifth.

"It appears, then, that the efficiency of a heat-engine is the product of three factors, viz: I. The *efficiency of the furnace*, being the ratio which the heat transferred to the working fluid bears to the total heat of combustion; II. The *efficiency of the fluid*, being the fraction of the heat received by it, which is transformed into mechanical energy; and III., The *efficiency of the mechanism*, being the fraction of that energy which is available for driving machines."

From the above discussion, we see immediately that by superheating the steam before it reaches the cylinder, we obtain a greater range of temperature for the steam to fall through in expanding, and thus render efficacious yet more of the heat of the furnace.

List of Works on the Conservation of Force and Thermodynamics.

The Correlation and Conservation of Forces; a collection of the papers of *Mayer*, *Helmholtz*, *Faraday*, *Grove*, *Liebig* and *Carpenter*. Edited by Dr. Edward L. Youmans, N. Y., 1865.

Joule.—On the Calorific Effects of Magneto-Electricity, and on the Mechanical Value of Heat. Phil. Mag., Vol. XXIII., 1843.

On the Changes of Temperature produced by the Rarefaction and Condensation of Air. Phil. Mag., May, 1845.

On the Mechanical Equivalent of Heat. Phil. Trans., 1850.

On some Thermodynamic Properties of Solids. Phil. Trans., 1859.

On the Thermal Effects of Compressing Fluids. Phil. Trans., 1859.

Clausius.—The Mechanical Theory of Heat, with its applications to the Steam Engine and to the Physical Properties of Bodies. Edited by T. A. Hirst, with an Introduction by Prof. Tyndall. London, 1867.

Thomson (William).—An Account of Carnot's Theory of the Motive Power of Heat. Trans. R. S., Edinb., 1849.

On the Dynamical Theory of Heat. Trans. R. S., Edinb., 1852.

Thomson and *Joule.*—On the Thermal Effects of Fluids in Motion. Phil. Trans., 1853.

On the Changes of Temperature experienced by Bodies moving through Air. Phil. Trans., 1860.

Rankine.—The Steam Engine and other Prime Movers. London, 1859.

Verdet.—Exposé de la Théorie Méchanique de la Chaleur. Paris, 1863.

Hirn.—Exposition Analytique et Expérimentale de la Théorie Méchanique de la Chaleur. Paris, 1865.

Saint—Robert.—Principes de Thermodynamique. Turin, 1865.

Bacon.—Novum Organum, De Formâ Calidi, book 2, aph. 20.

"Now from this our first vintage it follows, that the form or true definition of heat (considered relatively to the universe and not to the sense) is briefly thus:—Heat is a motion, expansive, restrained, and acting in its strife upon the smaller particles of bodies. But the expansion is thus modified: while it expands all ways, it has at the same time an inclination upwards. And the struggle in the particles is modified also; it is not sluggish, but hurried and with violence."

Locke.—"Heat is a very brisk agitation of the insensible parts of the object, which produce in us that sensation from whence we denominate the object hot; so what in our sensation is *heat*, in the object is nothing but *motion*."

Rumford.—Trans. R. S. Lond., 1798. Rumford placed a cannon in a water-tight box, so that it could rotate against a blunt borer firmly pressed against the bottom of its chamber. The box was filled with water of a temperature of 60° F., and the cannon set in rotation by the power of horses.

"The result of this beautiful experiment was very striking, and the pleasure it afforded me amply repaid me for all the trouble I had had in contriving and

arranging the complicated machinery used in making it. The cylinder had been in motion but a short time, when I perceived, by putting my hand into the water, and touching the outside of the cylinder, that heat was generated.

"At the end of an hour the fluid, which weighed 18·77 lbs., or 2½ gallons, had its temperature raised 47 degrees, being now 107 degrees.

"In thirty minutes more, or one hour and thirty minutes after the machinery had been set in motion, the heat of the water was 142 degrees.

"At the end of two hours from the beginning, the temperature was 178 degrees.

"At two hours and twenty minutes it was 200 degrees, and at two hours and thirty minutes it *actually boiled.*

"From the results of my computations, it appears that the quantity of heat produced equably, or in a continuous stream, if I may use the expression, by the friction of the blunt steel borer against the bottom of the hollow metallic cylinder, was *greater* than that produced in the combustion of *nine wax candles*, each ¾ inch in diameter, all burning together with clear bright flames.

"One horse would have been equal to the work performed, though two were actually employed. Heat may thus be produced merely by the strength of a horse, and, in case of necessity, this heat might be used in cooking victuals. But no circumstances could be imagined in which this method of procuring heat would be advantageous; for more heat might be obtained by using the fodder, necessary for the support of a horse, as fuel.

* * * * * "It is hardly necessary to add, that anything which any *insulated* body or system of bodies can continue to furnish *without limitation*, cannot possibly be a *material substance;* and it appears to me to be extremely difficult, if not quite impossible, to form any distinct idea of anything capable of being excited and communicated in those experiments, except *motion.*"

Davy.—First scientific memoir, entitled "On Heat, Light, and the Combinations of Light." Works Vol. II.

"*Experiment.*—I procured two parallelopipedons of ice, of the temperature of 29°, six inches long, two wide, and two-thirds of an inch thick; they were fastened by wires, to two bars of iron. By a peculiar mechanism, their surfaces were placed in contact, and kept in a continued and most violent friction for some minutes. They were almost entirely converted into water, which water was collected, and its temperature ascertained to be 35°, after remaining in an atmosphere of a lower temperature for some minutes. The fusion took place only at the plane of contact of the two pieces of ice, and no bodies were in friction but ice.

"From this experiment it is evident that ice by friction is converted into water and according to the supposition, its capacity is diminished; but it is a well-known fact that the capacity of water for heat is much greater than that of ice; and ice must have an absolute quantity of heat added to it before it can be converted into water. Friction consequently does not diminish the capacity of bodies for heat.

* * * * * * *

"Now a motion or vibration of the corpuscules of bodies must be necessarily generated by friction and percussion. Therefore we may reasonably conclude that this motion or vibration is heat, or the repulsive power.

Davy in his *Chemical Philosophy*, p. 95, says:

"* * * * The immediate cause of the phenomena heat, then, is motion, and the laws of its communication are precisely the same as the laws of the communication of motion."

A process similar to the above classical experiment of Davy, has from time immemorial been used by savage nations in obtaining fire by means of friction: not by *rubbing* together sticks, as usually stated, for no one could thus produce ignition, but by *whirling* rapidly, a pointed rod against a wooden block, by means of an arrangement similar to the watchmaker's bow and drill. It is worthy of remark that this apparatus has everywhere the same form, whether used by the islanders of the Pacific or by the aborigines of our own country. One of these instruments can be seen in the State Cabinet of Natural History of New York.

Henry (Dr. Joseph).—Meteorology—Patent Office Report for 1857.

On Acoustics applied to Public Buildings—Smithsonian Report, 1856, p. 228.

"The tuning-fork was next placed upon a cube of India rubber, and this upon the marble slab. The sound emitted by this arrangement was scarcely greater than in the case of the tuning-fork suspended from the cambric thread, and from the analogy of the previous experiments, we might at first thought suppose the time of duration would be great; but this was not the case. The vibrations continued only about forty seconds. The question may here be asked, what became of the impulses lost by the tuning-fork? They were neither transmitted through the India rubber nor given off to the air in form of sound, but were probably expended in producing a change in the matter of the India rubber, or were converted into heat, or both. Though the inquiry did not fall strictly within the line of this series of investigations, yet it was of so interesting a character in a physical point of view to determine whether heat was actually produced, that the following experiment was made.

* * * "And the point of a compound wire, formed of copper and iron, was thrust into the substance of the rubber, while the other ends of the wire were connected with a delicate galvanometer. The needle was suffered to come to rest, the tuning-fork was then vibrated, and its impulses transmitted to the rubber. A very perceptible increase of temperature was the result. The needle moved through an arc of from one to two and a half degrees. The experiment was varied, and many times repeated; the motions of the needle were always in the same direction, namely, in that which was produced when the point of the compound wire was heated by momentary contact with the fingers. The amount of heat generated in this way is, however, small, and indeed, in all cases in which it is generated by mechanical means, the amount evolved appears very small in comparison with the labor expended in producing it."

Leibnitz.—"The *force* of a moving body is proportional to the square of its velocity, or to the height to which it would rise against gravity."

Wollaston.—Bakerian Lecture on the Force of Percussion. Phil. Trans., Vol. XCVI., 1806.

"In short, whether we are considering the sources of extended exertion or of accumulated energy, whether we compare the accumulated forces themselves by their gradual or by their sudden effects, the idea of mechanic force in practice is always the same, and is proportional to the *space* through which any moving force is exerted or overcome, or to the *square* of the velocity of a body in which such force is accumulated."

Tyndall.—Heat considered as a Mode of Motion. New York, 1863.

I need hardly refer the reader to this charming exposition of Prof. Tyndall; who, by his enthusiasm and vividness of illustration, has rendered his subject so popular that his work is, in this country, in the library of nearly every man of culture.

(To be continued.)

NITRO-GLYCERINE: ITS CLAIMS AS A NEW INDUSTRIAL AGENT.

By John Mayer, F. C. S.

(Concluded from page 45.)

Many interesting observations were also made on nitro-glycerine, both in the protected and explosive states, by a Royal Commission, appointed from the Engineer Corps of the Prussian army. They were made in the year 1866, at Glogau, in Silesia. One or two of the experiments may be mentioned. Protected nitro-glycerine was poured into a tin vessel, seven inches square, and twelve inches high, and fired at with a breech-loading musket, from a distance of seventy feet, or thereabouts. At the first trial common, and at the second explosive, cartridges were used. When the ball struck there was no explosion in either case. "In order to ascertain its character of safety during transport, two conveyances of inexplosive nitro-glycerine were undertaken. The distance of the first tour, *via* Bauschwitz and Gurken, was about one German mile. The carts passed over macadamized roads, good and bad, and returned in about one hour. A tin bottle, containing three and a half ounces of protected nitro-glycerine, was put into an old powder-box, and secured in such a manner as to admit of its moving backwards and forwards without falling down; nor was it entirely filled. The powder-box was attached to the hind axle-tree of a wagon with racks. Every pace of the horses was tried without any explosion taking place. At the second trial four horses were put to an Austrian ammunition wagon. One pound of inexplosive nitro-glycerine was put into this wagon, in a tin bottle, one-third empty, and the latter secured so as to allow it to move to and fro without falling down. This trip was somewhat longer, the cart going over about two German miles of ground. The cart was driven intentionally over the very worst parts of the road, and at the most rapid pace. On the road the bottle was inspected and was found to leak at the mouth. By this means, some blasting liquid had accumulated at the bottom of the wagon, which by evaporation must have become explosive. But, as even explosive nitro-glycerine does not explode on wood, when struck ever so hard with a hammer, the trial was continued. In order to

ascertain finally whether a prolonged uniform movement leads to a result different to that of violent shocks, the cart was driven from Bauschwitz to the scene of the experiments, about half a German mile, half of the road stone pavement, in a sharp but regular trot. No explosion took place."

The transformation of protected into ordinary nitro-glycerine is effected by thoroughly agitating it with water, and allowing the mixture to settle for a short while. By this means the water dissolves out the methyl-alcohol, and the mixture of spirit and water readily rises to the surface, in virtue of its low specific gravity, and can be removed by means of a siphon, or by simply pouring it off. The blasting liquid is now ready for use. It would seem that the methyl-alcohol is by this means separated very readily from the nitro-glycerine held in solution by it. If protected blasting liquid be kept in a closed vessel, it will remain in that state for an indefinite period of time, and ready at any moment to be reduced or rendered fit for action; if, however, it be exposed in an open vessel, it will regain its explosiveness, in periods of time proportionate to the amount or degree of exposure. In the experiments, for instance, which were instituted by the Prussian Military Commission, it was observed that protected nitro-glycerine, exposed to the air in an open glass, only acquired explosiveness on the twenty-first day, although it was tried every second or third day; and such protected liquid, after being exposed in an open bottle with a narrow neck for twenty-one days, exhibited no tendency to explosion even then,—thus showing that comparative confinement of the liquid very greatly retards the evaporation of the solvent and protecting wood-spirit.

As an explosive capable of being practically used, nitro-glycerine is quite an exceptional substance, from the circumstance of its being a *liquid* compound. There are other liquid explosives,—as the so-called chloride of nitrogen, for instance,—but nobody has ever yet succeeded in practically applying them, or even ventured to prepare any of them in large quantity. The force exerted by nitro-glycerine, during an explosion, is truly marvellous; indeed, no correct conception can be formed of it by any person who has not himself experimented with it, or has, at all events, seen the experiments performed. Weight for weight, the new explosive is ten times more powerful than gunpowder. The extraordinary mechanical or eruptive power which it exerts is partly owing to the fact that there is no solid residue attending the explosion, and that the enormous pressure exerted by the resulting gases is due to the great rapidity of the explosion. The rocks being blasted have not time enough permitted them to effect any sensible cooling and condensing of the vapors. In fissured rocks this rapidity of explosion is of immense consequence; it is so very great that the tamping employed in blasting operations, is in many cases not ejected from the bore-holes, although—by preference—it is almost invariably quite

loose, consisting of sand, slate-dust, or other finely divided solid matter, or even ordinary water.

Hard tamping is of comparatively little use, owing to another very curious property possessed by nitro-glycerine, namely, that of "striking down," as it has been called, or of exerting its explosive force—unlike gunpowder—almost entirely in a downward direction. This circumstance is intimately connected with the explosion on board, and ultimate destruction of, the steamship 'European' at Aspinwall. The nitro-glycerine taken by that vessel from Liverpool was placed in the very bottom of the hold, owing to its being shipped as a liquid. There is not room here to discuss all the *pros* and *cons* of that catastrophe; but one or two facts may be mentioned, as they have great scientific and practical interest, and some of them, although brought out at the Liverpool trial last summer and made public, have been misinterpreted. It is known that, besides the seventy-two 28lb. cases of nitro-glycerine, there were some 20,000 percussion caps and other combustible substances on board. It is also known that there were three explosions, the first being very loud, and occurring about twenty minutes before the second, which was not nearly so loud, and the the third and last occurring *after the vessel had taken fire*, and had been for some time out at sea, where she had been towed by another steamer, and where she continued to burn, and eventually went down. The nitro-glycerine confined in the hold of a large iron steamer in such a warm climate, would necessarily be in a somewhat sensitive state. The spontaneous combustion theory set up at the Liverpool trial, and supported by Professors Abel and Roscoe, is not necessary to account for the results. The first explosion was certainly due to nitro-glycerine, a case of which was being hoisted up by a steam crane, and with such rapidity that when near the deck it struck against a beam and immediately exploded, when it was observed that two iron plates were blown off the top of the vessel on the port side and near the stern. There seems to be no room for doubting that the last explosion was also caused by nitro-glycerine, when the loudness of that explosion—it was louder than the second—is borne in mind, as also the intense heat of the burning ship, the position occupied by the remaining seventy-one cases of the liquid, the "striking down" character of an explosion of nitro-glycerine, and the fact that the said explosion caused the ship to go down. That it did not seem so loud as the first explosion, is accounted for by the circumstance that the ship was not then lying at the wharf, but was some distance out at sea, and by the fact, also, that the nitro-glycerine was at the very bottom of the hold, at least ten or fifteen feet below the surface of the water.

Had we space at command, it would be profitable to discuss the facts and suppositions connected with the Newcastle explosion, as that occurrence is invested with a great amount of interest. The

evidence at the coroner's inquest—as at the Liverpool trial—brought forth the usual theory of spontaneous decomposition, supported by the stock arguments. As we happen to know something of the history of the Newcastle nitro-glycerine, we may oppose a few facts to the fiction which the Newcastle coroner was compelled to listen to. To do so may possibly disabuse the minds of some persons of the prejudices acquired by the untoward event of December last. The nitro-glycerine in question was manufactured at Hamburg in the usual way, mixed with methyl-alcohol, and shipped as inexplosive blasting liquid, at the commencement of the winter 1866–7, on board a vessel which, on account of an accident, had to put into Harwich, where the cargo was received into two lighters, and remained about two months exposed to the severest weather of the season. One of the cases was opened at Harwich, in order to get a sample, but that was found to be an impossibility, as the contained nitro-glycerine was a perfectly solid ice-like mass. The weather had apparently destroyed the effect of the methyl-alcohol. When the substance was conveyed to Carnarvon, part of it was washed with water in the usual way, to remove the alcohol, as if it were still protected. But that was found to be unnecessary. The slate quarrymen fired it with gunpowder without any difficulty, and it was evident that the effect of the alcohol, if not entirely destroyed was nearly so. Twenty-four of the cases—6 cwt.—were sent into the Newcastle district in July last. A large portion of it, as is now well known, was stored in the town of Newcastle, in contravention of the provisions of the "Carriage and Deposit of Dangerous Goods Act, 1866." At the fatal Town Moor, three of the tin cases, the tops of which were strongly soldered down, were forcibly opened by means of a spade, and found to contain a quantity of solid nitro-glycerine. In this state, practical men know it to be more difficult to explode than when in the liquid state; but that it resisted such violent treatment is almost inconceivable, and that Sub-Inspector Wallace is still living is little short of a miracle. Is it possible that any sane person can believe that the crystallized nitro-glycerine after such a rough career and such violent usage could explode spontaneously? that it was so sensitive that the simple slipping or friction of one piece upon another brought about the fatal explosion? We sincerely hope not.

That nitro-glycerine has properties of peculiar value in blasting operations may be inferred from the following facts:—

The first and most successful company formed for the manufacture of the substance, is one formed at Stockholm, towards the end of the year 1864, and the shareholders in which are *all Swedish miners*, with the exception of one who is the director of the Stockholm Private Bank. The shares are much in request, but they are not in the market, and cannot be had, and the dividends are greater than the directors care to tell. The rapidity with which the Swe-

dish miners took to the use of the new blasting agent is most extraordinary. The great tunnel of the Central Railway through Stockholm was blasted throughout with nitro-glycerine made by that company. A stupid accident occurred—not an explosion of the blasting liquid—which frightened the authorities so much that a royal order was issued that no more than two pounds of nitro-glycerine should be stored in one place within the city; but the workmen declared, one and all, that they would resign rather than work again with gunpowder for the same pay. For a few days, the royal order remained in force, but it was then cancelled by dint of necessity, and the work of the tunnel proceeded to completion—the greatest underground work executed by the new blasting agent. Mr. Eric Unge, the chief engineer and managing director, speaks very highly of the advantages of using nitro-glycerine, including amongst them the saving of 23 per cent. on the cost of blasting, and 87 per cent. greater speed than with the use of gunpowder.

In the largest slate quarries of North Wales—some of them of immense extent—a larger amount of money is spent yearly on nitro-glycerine than on gunpowder for blasting purposes; and in many cases the men make their bargains dependent on the quarry proprietors, undertaking to guarantee a supply of nitro-glycerine. Tons of this substance are used annually in the Welsh slate quarries, and yet accidents from its use, or rather its abuse, are almost never heard of. At the Penrhyn and Dinorwic quarries, one quarter of a ton per month is used. Mr. Parry, the manager of the Dinorwic quarries, was recently asked about the danger of using nitro-glycerine as a blasting agent. He said they never had an accident with it, while the accidents from gunpowder were so numerous during the past year, that he really could not tell how many there had been.

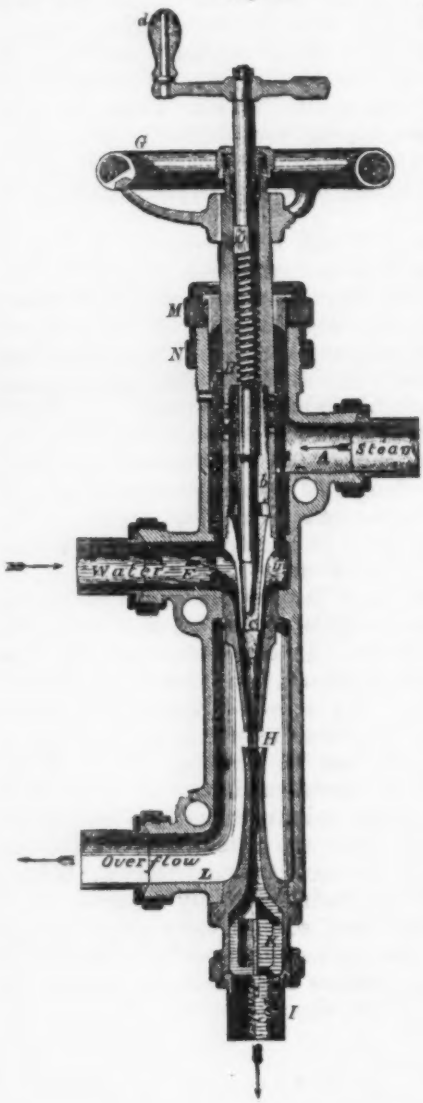
These are only samples of scores of facts which might be quoted in respect of the safety, the remarkable properties, and extensive use now attained by nitro-glycerine. In concluding, we may use the language of one of our correspondents, who favors us with his experience as a practical man. He says:—"Miners may have dreamed of a blasting material ten times as strong as gunpowder, exploding with such velocity as to need no tamping, unaffected by water, blasting seamy as well as the hardest and most solid rock, and leaving no smoke; but surely in this substance the very properties most needed are realized to such an extent as to appear utopian or extravagant to all those who have not tried it for themselves. Whatever its drawbacks may be, nitro-glycerine certainly deserves a fair and liberal investigation. Nature and science have placed at our command one of the most powerful agents ever sent forth from their united laboratory; neighboring nations have learned to tame its somewhat rebellious nature, and why should not we follow the example which they have set us?"

THE GIFFARD INJECTOR.

(Continued from page 58.)

HAVING thus considered the theory of this apparatus, we will now describe its actual structure and operation, and first in its original form.

Fig. 3.



Referring to the cut, Fig. 3, which exhibits a section of the apparatus as formerly manufactured by the Messrs. Sellers, of this city, we see, first, a pipe, A, by which steam is admitted from the boiler, and passing through orifices cut between the threads of the hollow screw, B*b*, enters the space, *b*, from which it passes out by the conical nozzle, C, its flow being regulated by adjustment of the conical rod or plug, controlled by the handle, *d*, and screw-thread, OB. At E is another pipe supplying water to the annular space about C, from a reservoir, not more than 5 feet below, from which it may pass out by the conical nozzle, FH, its amount being regulated by the position of the tube or nozzle, C, which is controlled by the hand-wheel, G, and screw-thread. Opposite and in line with the nozzle, FH, is a conical tube, having a valve, K, at its further end, from which the pipe leads to the water space of the boiler. Around the two last-named conical tubes, or nozzles, is

a casing, which serves to connect the parts, and has an outlet or overflow, L, to be noticed presently.

The operation of this instrument is as follows: By almost closing the annular opening around the nozzle C, and opening the steam-cock to the boiler so as to allow a little steam to pass out of the nozzle, C, we produce a partial vacuum in EF, by which water is drawn up into, and delivered from, the nozzle into the space around H, from which it escapes by the overflow, L. More steam and water being let on, the condensed steam and water uniting in the combining tube, F, acquire such velocity as to enter HK, and opening the valve, pass into the boiler.

When the supply of steam and water is properly adjusted, all escape from the overflow will cease.

If the water supply is in excess, some water will escape by this outlet, so indicating a waste of material and force; while, if the steam is in excess, a partial vacuum and indraft of air will occur, thus showing that the apparatus is not performing its maximum duty in forcing water into the boiler.

The amount of water which can be driven into the boiler will vary with the pressure, and, therefore, under changing conditions of pressure, frequent adjustment will be required to keep the apparatus in operation and to obtain a maximum effect. The reason of this variation in effectiveness with change of pressure will be evident, if we refer to our previous explanation on p. 57. It was there shown that, in one view, the efficiency of this instrument depended upon the contraction of a large volume of steam into a small volume of water, whereby the pressure exerted upon a large area of exit was concentrated upon a smaller one of entrance. Now it is clear, that the lower the pressure in the boiler the greater will be the volume of the escaping steam, and, therefore, the greater the amount of its concentration in condensing. By an increase of pressure, it is true, we increase the velocity of the escaping steam; but we also, by the same means, increase the resistance or pressure opposing the entrance of the water into the boiler.

It therefore appears, that from the theoretical considerations involved in the explanation given before, we might anticipate what we find in practice to be the fact, namely, that the largest amount of water, in proportion to the steam escaping, can be injected with the lower pressure.

Of course, with the greater pressure, the *amount* of steam passing out is greatly increased, and thus the actual amount injected is

somewhat increased, while what we may call the "duty" of the steam employed, falls off. Thus a No. 2 Injector, with 30 pounds of steam pressure, throws 9·7 cubic feet water per hour, and with 150 pounds, throws 18·1. The amount of water discharged being less than double, while the pressure is increased five times.

In locomotive boilers, and others, having a small water and steam capacity, compared with their heating surface, the necessity for re-adjustment of the water supply by the attendant, indicated and discussed above, becomes a serious inconvenience, especially when, as in the case cited, great and frequent changes occur in the steam pressure.

To obviate this difficulty, and to render the apparatus self-adjusting, with reference to the water supply, so that it would always be giving a maximum delivery, under changing conditions of pressure, has long been desired, and has at last been accomplished in the apparatus devised by Mr. William Sellers; which we shall now proceed to describe.

It was long known, that when the supply of water was somewhat less than that which the injector was capable of throwing at the time, a partial vacuum was formed in the chamber surrounding the nozzles, so that if the hand were held against the waste-pipe, an indraft would be sensible. Here then, clearly, was a force which might, in some way, be applied in regulating the water supply in one direction, that is, by increasing it when insufficient. This alone, however, would not answer; an opposite force must also be supplied, by which the inflow of water, when too great, might be checked.

The existence of an action by which such a force might be developed, was discovered and demonstrated by Mr. Sellers, in the following manner:

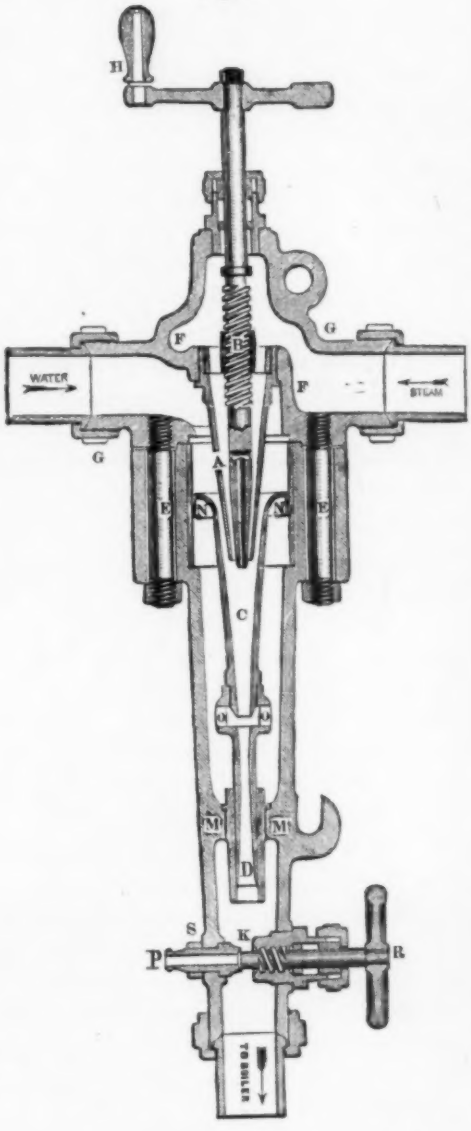
An Injector was provided with a pressure-gauge, in connection with a space around the discharging and receiving pipes, and with a stop-valve upon the waste-pipe.

The instrument being so adjusted that its water supply was in excess, and a quantity of water, therefore, discharging from the waste-pipe, the stop-valve was then partially closed, until the excess of water collected in the chamber and produced pressure on the gauge, when it was found that the Injector would continue to act, and to force water into the boiler even when the pressure in the chamber nearly equaled that of the boiler.

Here, then, was the force required, and we will proceed to describe the arrangement of apparatus by which it was caused to develop, with ease and certainty, the desired effect.

A glance at the accompanying section will show how vital an alteration the instrument underwent in the new modification.

Fig. 4.



The outer shell or case consists of two parts, united by bolts, EE. The part GG is provided with two inlets, the one for steam, the other for water, as shown in the cut, the two being separated by the plate, FF, in the centre of which is attached a nozzle, A, for the steam jet. The amount of steam which may be discharged by this nozzle, is regulated by the tapered plug which is operated by the screw, B, and exterior handle, H. The interior of the case, EE is bored out for a short distance, and fitted with a lining of brass, turned out to receive the piston, NN, which plays freely along it. This piston forms the upper or receiving end of the converging pipe, C, called the combining tube which is connected at its smaller end with the diverging or discharging tube, D. This tube is cylindrical on its exterior, and plays freely in the brass bushing of MM, secured in the casting or outer shell, as shown in the cut.

Beyond this point again, a small stop-valve, P R, affords, when open, a lateral outlet to the tube, K; and beyond this again, a check-valve, is placed between the instrument and the boiler.

To put this apparatus in operation, the stop-valve, P R, is opened, and the steam plug, B, is closed; a little steam being let in, will escape through the small hole in the end of the steam plug, producing a vacuum, when the water is drawn up and forced through C and D into the pipe, K, from which it escapes by P. The plug, B, is then drawn back, so increasing the supply of steam, until the stop-valve, P, can be closed, without causing the injector to cease working. This ceasing to work will be indicated by an escape of steam from the water supply pipe. The action which is taking place in the apparatus, when thus in operation, may be briefly described as follows:

The steam passing into C is condensed by the water there combining with it from the water supply and the concentrated jet, is then driven through the delivery tube, D, into the pipe, K, from which, by raising the check-valve beyond, it passes into the boiler.

If, now, the water supply is, or becomes, too great; a portion of water escapes by the opening, O, in the portion connecting the combining and delivery tubes, and accumulating in the surrounding chamber, forces back the piston, N N, which, of course, carries with it the tube, C, &c., thus diminishing the annular space through which the water enters the combining tube, and so limiting its supply. If, on the other hand, the supply of water is not sufficient, the velocity of the steam jet will be increased and a partial vacuum will be produced in the chamber, and the piston, N N, will consequently be brought downward, thus opening the space for water supply, and correcting the defect.

We thus see that the instrument is self-regulating, and will adapt itself to changed conditions of pressure, so as always to develop a maximum result proportioned to the quantity of steam used.

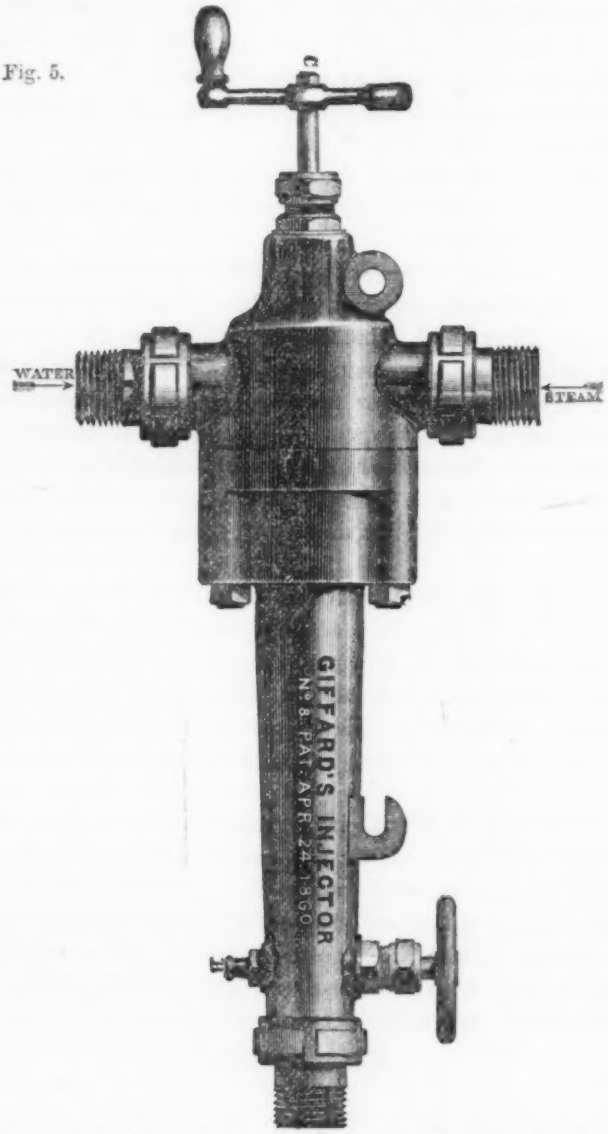
There are, besides this general principle and action, several other points claiming notice in this form of the instrument.

Thus it will be observed, that the conical plug, B, for regulating the steam supply, has a narrow passage bored along its axis, which communicates, by transverse openings, with the steam space around it.

By this means, when the plug, B, is forced all the way down, so as to close the outlet of A, a small jet of steam will pass by the opening in the plug, and will exert a much greater lifting force to raise

water from the supply into the combining tube, C, than will be produced by a jet of steam through the annular space between the plug, B, and nozzle, A.

Fig. 5.



The reason of this is, in part, as follows: To produce this lifting effect, which is quite dissimilar from that of the Injector in its ope-

ration connected with the introduction of water into the boiler, and is more nearly allied to the action of the exhaust in producing a draft in the smoke-stack of a locomotive; the effect depends chiefly on the free expansion and high velocity of the steam jet at the moment it escapes from the nozzle, A, (or the centre of plug, B,) and upon the existence of an outlet beyond, C, not only sufficient to allow this expanded sheaf-jet to pass freely, but also to give exit to the air carried with it by friction.

Now, in all these respects, the annular jet between the plug, B, and nozzle, A, is at great disadvantage, as compared with the orifice in the centre of plug, B.

Thus the friction is immensely greater in the annular jet, thereby reducing the velocity, especially if this jet is but slightly open; while on the other hand, if more space is given in the annular jet, the amount of steam discharged will be more than can pass freely by the nozzle, C, thus rather tending to produce a back pressure than a vacuum in C and the water supply pipe. In fact, it is found that where, with the old arrangement, an injector is able to raise its feed (water) from 2 to 6 feet, with this modification, it will lift its supply from 10 to 18 feet, depending upon the size of the instrument.

The exterior appearance of this instrument is shown in Fig. 5.

Having thus discussed, in a general way, the structure of the simple Injector itself, we will next pass to a consideration of those appliances which are as essential to its successful use and certainty of operation as similar appliances are to the efficient working of any of the old and familiar instruments, such as the ordinary pump.

This subject is of special importance, because it is so apt to be overlooked and neglected, for the reason that the novelty of the instrument here considered, makes it impossible that experience and tradition (as we may call it) should have thoroughly informed the mechanical public at large as to all the relations of this subject, as they have been informed with regard to apparatus longer in use, because of an earlier date.

(To be continued.)

EDUCATIONAL

SUNLIGHT AND MOONLIGHT.

A Lecture delivered at the Academy of Music, before the Franklin Institute, on May 23d and June 6th, 1868.

By Prof. Henry Morton, Ph.D.

(Continued from page 64.)

Having discussed the characteristics of reflected light, we will now pass to the revelations which the light reflected by the moon makes as to the present state and past history of that satelite.

When the sun's rays fall vertically upon that portion of the moon which is exposed to our view, no shadows can be projected by the inequalities of surface, and all differences in appearance between various portions will depend upon specific differences in reflective power, and upon the angle at which the surfaces are presented to the incident rays.

This is the condition we find in the full moon. Thanks to the genius and also to the kindness of Mr. Lewis A. Rutherfurd, I am able to bring before you the very image of the moon, not only with the seeming brightness of nature, but with such enlargement of apparent size, that each one in the house will be able to perceive every detail as though looking through a telescope of great power. With reference to the production of these moon photographs, I shall have more to say presently, but first we will consider what they are and what they teach us. We will begin with the full moon, because that gives us a general view, and is most quickly disposed of, all detail being deficient from the absence of shadows, as explained above.

[A vast full moon, thirty-five feet in diameter, here seemed to glide in upon the stage, being projected upon the screen with such success, that notwithstanding its great size, it had a silvery or snowy brightness such as distinguishes the actual luminary. The glass picture employed was made by Mr. O. H. Willard, from one of Mr. Rutherfurd's negatives.]

The circumstance which I presume first of all strikes those unac-

customed to a telescopic study of the moon, is the entire *unlikeness* of this image, to the moon as seen with the naked eye. All resemblance to a human face has vanished, and in its stead we have a marked similarity to an orange, denuded of its rind.

This change of aspect is not peculiar to the photograph, but appears equally to the eye when its visual power is increased by the aid of the lenses in a telescope. In either case, the cause is the same, *i. e.*, marked details not before visible, attract the attention and obliterate the general impression which alone was realized before. Thus the strong luminous rays, which you perceive radiating from various points, are imperceptible to the unaided eye, while in the telescope they are the most characteristic features exhibited.

The cause of these luminous rays is by no means certainly determined otherwise, than that they result from a greater reflecting power in the lunar soil where they are traced; but how this more highly reflecting material came to be thus placed and distributed we can only conjecture. Certain significant facts may, however, well receive our notice.

All these rays or systems of luminous lines diverge from great volcanic centres. Thus the principal group has at its centre the volcano Tycho, whose interior basin or crater is fifty-four miles in diameter, with precipitous walls of 17,000 feet in height, and a central cone whose summit rises abruptly 4,000 feet above the interior plain.

The centres of the other marked systems are Copernicus, Kepler, Aristarchus, Anaxagoras, Petavius and Proclus.

In the next place, we find that one series of rays overruns and obliterates parts of another. Thus rays from Tycho obliterate those from Copernicus, never the reverse. Rays from Aristarchus obliterate those from Copernicus, while rays from Copernicus never obliterate those from Aristarchus.

Whatever, then, be the cause of their formation, they are at least intimately connected with these central mountains, and have been developed in such an order of sequence as the above statement indicates, Tycho being the last born of these volcanic giants.

Another and most perplexing feature of these luminous markings is, that they are neither ridges nor valleys, but coincide with the surrounding levels so as to produce no shadow at any time during the progress of the sunlight over the surface of the lunar globe.

Were the luminous bands hollow, we would say they were clefts produced by the volcanic action recorded so clearly at their respective centres, filled partly with white or polished lava. Were they ridges we would suppose them to be the result of cracks through which quantities of fluid rock had been forced up from below. But that the fresh material should have followed so closely the contour of the surrounding parts, requires other and more elaborate hypotheses to complete an explanation.

We may, however, well rest assured that these markings are the result of violent convulsions, having these various craters as their centres, by which the lunar crust was split open, and the interior, still fluid lava, extruded. Subsequent craters were formed in and encroached upon these markings, so giving them a broken and irregular appearance, but yet leaving their general shape and direction perfectly manifest.

It is only, however, at or near full moon that these markings show themselves in the power and distinctness of the picture which you now see upon the screen; at other times, only a few of them are strongly delineated, many are almost obliterated, and some quite disappear. The reason of this is obvious. These markings depend for visibility simply upon an unequal reflecting power on the surface. Now it is quite possible, from analogy with known substances within our reach, that this difference diminishes with an increase in the obliquity of the incident light. Thus with glass and black marble polished, the proportion of light reflected by the two substances at an angle of 30°, is 11 : 5, at 15° 30 : 15, and at 5° the proportion has reversed itself, being 54 : 60, that is, the marble here reflects most.* This example shows the possibility of what we suggest. Different bodies act in various and arbitrary ways in this respect, and as we do not know what is the nature of the lunar surface, we can only offer this as a conjecture. A more important cause of obliteration is however found in the strongly contrasted lights and shadows which cover the visible portion of the moon in her other phases, which would tend to mask and render imperceptible such slight differences of tint as these which we have been describing.†

* Daguin T. IV. p. 45.

† We have made no attempt to reproduce the photographic picture of the full moon, because, while such an engraving would be expensive and troublesome, it would be at best unsatisfactory and uninteresting, and if not executed with the greatest skill, a pictorial failure also, as is indeed the case with all the representa-

The phenomena of luminous streaks having been thus considered, we will call for another phase, which will serve us better in our continued investigation and study of other features.

[At a signal from the lecturer, the picture of a full moon was replaced by another, showing the appearance at a certain point of the third quarter. (See Plate II.) This was from a photograph made by Mr. Rutherfurd, on the 6th of March, 1865. The glass picture employed was prepared by Mr. O. G. Mason.]

In the first place, you will, no doubt, remark that this looks as little like the familiar moon, with its ugly human face, as did the orange-like full moon which it has replaced. We shall, however, be able to trace the most important features of our amiable satelite in this likeness with no more effort, perhaps, than is required for the recognition of a familiar face, in the first essay of many an amateur photographer.*

Thus we find the right eye of the moon's face in the partly shown circle of the Mare Imbrium, the left eye in Mare Serenitatis and Mare Tranquilitatis, the mouth in the southern portion of the

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tions which have been yet published, which look as little like the moon as an irregularly shaded circle well can.

We have therefore preferred to expend our time and the means at our disposal upon reproductions of the other phases, which offer a better opportunity to the artist, and are moreover of infinitely greater use to the student, because showing those details of structure and topography which are wanting in the full phase.

Plate II. which accompanies this number of our *Journal*, is a carefully reduced copy of the photographic print made by O. G. Mason, of New York, from a negative taken by Rutherfurd, on the 6th of March, 1865.

Some of the details at a distance from the terminator (dividing edge of illumination and shadow), are more fully defined than they could be in the phase here shown, by reference to another print of an earlier phase, prepared also by Mr. Mason, from a negative bearing date March 4th, 1865, and like the former and others to be described in future, kindly presented to us by Mr. Rutherfurd.

In the accompanying plate II., will be seen some few of these luminous rays, the most marked proceeding from Tycho near the South Pole, another set from Petavius (60) near the south-west border, and another from Proclus (near 78), on the eastern border of the Mare Crisium. As we have already stated, these markings would be vastly more numerous and distinct in a view of the full moon, but this will serve to indicate their character.

* In comparing what immediately follows with the plate, it must be remembered that for convenience of reference, this is lettered in the position in which it is seen in the telescope (*i. e.*) inverted from its natural attitude. To compare this plate, therefore, with the moon, as seen by the naked eye, we must turn the plate so that the lettering will be upside down.

Mare Nubeum, the very irregular profile of the nose in the plains which stretch north and south along the terminator, and the marked dimple in the chin appears as no less than that grand volcanic centre, Tycho.

Having then assured ourselves of the truthfulness of the picture, let us next consider those details which have nothing to do with this likeness to the familiar moon, since they are only visible in the telescope or the photograph.

These darker regions of a circular form are still called and were once believed to be seas, but we now know them to be simply arid wastes, owing their deeper tint to a darker color, or the less reflective character of their soil. Their universally circular form leads us to believe that they are only enormous craters of ancient volcanoes, on the wall and over the area of which, lesser and subsequent eruptions have formed smaller cones and rings.

Such a condition of things we find, in fact, repeated in most of the smaller volcanoes, whose ramparts and plateaus are dotted with smaller cones. [It is impossible, however, to represent these correctly on so small a scale as in Plate II. The names of these various so-called oceans, and the ranges which border them, will be found on the plate, and also on the page facing it, as also the names corresponding to the numbers by which the individual peaks and smaller objects are indicated.]

This circular form of all mountain ranges, is one of the many characteristics by which the lunar topography departs from all terrestrial analogies. The characteristic of our mountain ranges is their general rectilinear direction and frequent parallel arrangement; but in the moon no instance of such a formation is to be found.

Another point which impresses itself strongly, is the absolute blackness of all shadows. We do not here refer to *shades*, such as are due to differences of surface and are found with every variety of gradation, but to the veritable shadows cast by ranges, rings and cones, and which are absolutely black and without detail.

The origin of this is to be found in two conditions, the absence of an atmosphere, by reason of which there is no diffused light reflected from the sky, by which, in our own case, terrestrial shadows are illuminated; and the vast distances of objects from one another, by reason of which the light which one reflects is scattered and lost before it can reach the other.

(To be continued.)

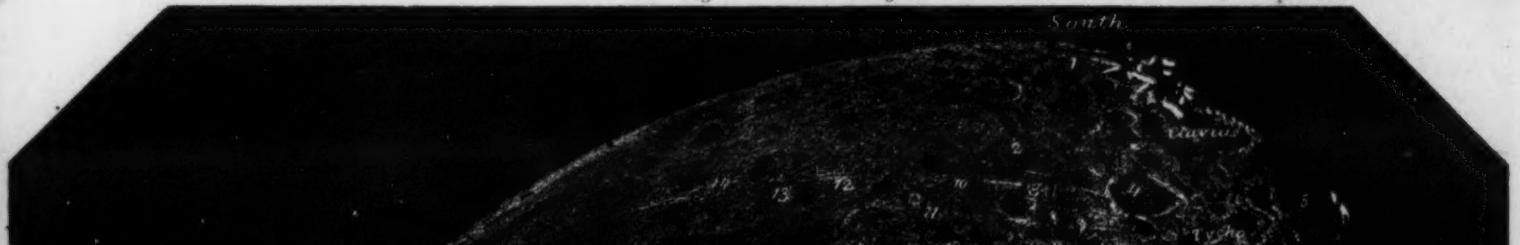
KEY TO PHOTOGRAPHIC LUNAR MAP.

The accompanying plate is at once a photographic view and map of the moon. It is, in the first place, a copy made with the greatest care from one of Mr. L. M. Rutherfurd's moon photographs, 20 inches in diameter, and upon this the names and numbers of reference have been inserted by reference to the unequaled moon map of Beer and Maedler. The position given to the plate is that of the moon as seen in the telescope, as it is then only that the details shown are visible. For comparison with the moon, as seen by the unaided eye, the plate should be simply inverted, so that the lettering is upside down. The numbers begin at the South pole, and, after going over that region, continue in progression by an irregular path, near the edge of the luminous portion, to the number 49, after which they go back to the southern part for 50, and then again descend to the northern region.

We give a list of the names engraved on the plate, to assist reference. Beginning with the region about the South pole, and go end downward and from left to right, we have:—

Clavius, Tycho, Pyrancei Montes, Mare Nectaris, Altai Montes, Mare Nubium, Mare Fœcunditatis, Mare Tranquilitatis, Mare Vaporum, Copernicus, Mare Crisium, Taurus Montes, Mare Serenitatis, Hœmus Montes, Apenninus Montes, Mare Inbrium, Lacus Somniorum, Locus Nortus, Caucasus Montes, Alpes Montes, Plato Mare Frigoris.

1. Maretus.
2. Zach.
3. Lilius.
4. Maginus.
5. Longomontanus.
6. Wilhelm I.
7. Saussure.
8. Nasireddin.
9. Stofler.
10. Cuvier.
11. Clauraut.
12. Baco.
13. Pitiscus.
14. Vlacu.
15. Maurolycus.
16. Lexel.
17. Walter.
18. Aliacensis.
19. Werner.
20. Gauricus.
21. Hell.
22. Pitatus.
23. Purbach.
24. Thebit.
25. Arzachel.
26. Alpetragius.
27. Davy.
28. Guerike.
29. Parry.
30. Alphons.
31. Ptolemaus.
32. Herschel.
33. Lalande.
34. Mosting.
35. Pallas.
36. Bode.
37. Stadius.
38. Eratosthenes.
39. M. Wolf.
40. Timocharis.
41. Archimedes.
42. Autolycus.
43. Aristillus.
44. Theœtetus.
45. Cassini.
46. Calippus.
47. Epigenes.
48. Anaxagoras.
49. Barrow.
50. Albategnius.
51. Abulfeda.
52. Almanon.
53. Geber.
54. Azophi.
55. Abenezra.
56. Playfair.
57. Apianus.
58. Picolomine.
59. Furnerius.
60. Petavius.
61. Fracastor.
62. Sanbeth.
63. Vendelinus.
64. Langranns.
65. Cook.
66. Gœlenius.
67. Guttemberg.
68. Theophilus.
69. Kant.
70. Affraganus.
71. Taylor.
72. Sabine.
73. Arago.
74. Agrippa.
75. Triesnecker.
76. Ross.
77. Vitruvius.
78. Palus somnii.
79. Macrobius.
80. Rômer.
81. Posidonius.
82. Bessel.
83. Linné.
84. Burg.
85. Hercules.
86. Atlas.
87. Endymion.
88. Eudoxus.
89. Aristoteles.
90. Copheus.
91. Franklin.
92. Berzelius.



Mare Imbrium
Mare Nectaris
Mare Tranquillitatis
Mare Crisium
Mare Fecunditatis
Mare Serenitatis
Mare Vaporum
Mare Humorum
Mare Nubium
Oceanus Procellarum
Mare Frigoris
Mare Humboldtianum
Mare Orientale
Tycho
Copernicus
Kepler
Aristarchus
Plato
Archimedes
Eratosthenes
Timocharis
Aristoteles
Eudoxus
Hercules
Atlas
Endymion
Petavius
Langrenus
Vendelinus
Furnerius
Gassendi
Mersenius
Riccius
Grimaldi
Letronne
Hevelius
Cavalerius
Encke
Gambart
Lansberg
Seleucus
Repsold
Harpalus
Bianchini
Hansteen
Olbers
Pitatus
Hyginus
Agrippa
Sosigenes
Rhaeticus
Rheinhold
Lalande
Maurolycus
Barocius
Stöfler
Faraday
Clavius
Drebbel
Blanchinus
Casatus
Moretus
Short
Young
Mayer
Pentland
Philolaus
Baco
Mercator
Hahn
Albategnius
Ukert
Gruithuisen
Hipparchus
Delambre
Sirsalis
Campanus
Reaumur
Horrebow
Rümker
Wargentin
Encke
Mitchell
Airy
Sharp
Herschel
Lee
Lohrmann
Kunowsky
Buch
Gay-Lussac
Rocca
Descartes
Cavendish
Fabricius
Janssen
Metius
Drebbel
Snellius
Gauricus
Rothmann
Santbech
Capuanus
Walter
Regiomontanus
Arzachel
Alphonsus
Ptolemaeus
Purbach
Werner
Aliacensis
Arnold
Hell
Lichtenberg
Orientale
Schiller
Zucchius
Inghirami
Kircher
Athanasius
Dionysius
Fontana
Byrgius
Bürg
Abulfeda
Almanon
Mosting
Manilius
Menelaus
Autolycus
Aristillus
Cassini
Conon
Eratosthenes
Timocharis
Diophantus
Carpathian Mts.
Alps
Apennines
Caucasus
Altai Mts.
Leibnitz Mts.
Rook Mts.
Doerfel Mts.
Cordillera
Pyrenees
Riphaean Mts.
Lemnius Mts.
Taurus Mts.
Haemus Mts.
Hadley Rille
Rupes Recta
Straight Wall
Sinus Iridum
Sinus Roris
Sinus Aestuum
Sinus Medii
Sinus Asperitatis
Sinus Amoris
Sinus Concordiae
Sinus Successus
Sinus Honoris
Sinus Fidei
Sinus Lunicus
Sinus Aurorae
Sinus Roris
Lacus Somniorum
Lacus Mortis
Lacus Timoris
Lacus Felicitatis
Lacus Gaudii
Lacus Spei
Lacus Luxuriae
Lacus Odii
Lacus Excellentiae
Palus Somnii
Palus Nebularum
Palus Putredinis
Palus Epidemiarum
Palus Putredinis
Palus Epidemiarum
Palus Somnii
Palus Nebular

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24. Thebit.
25. Arzachel.
26. Alpetragius.
27. Davy.
28. Guerike.
29. Parry.
30. Alphons.
31. Ptolemaus.
32. Herschel.
33. Lalande.
38. Eratosthenes.
39. M. Wolf.
40. Timocharis.
41. Archimedes.
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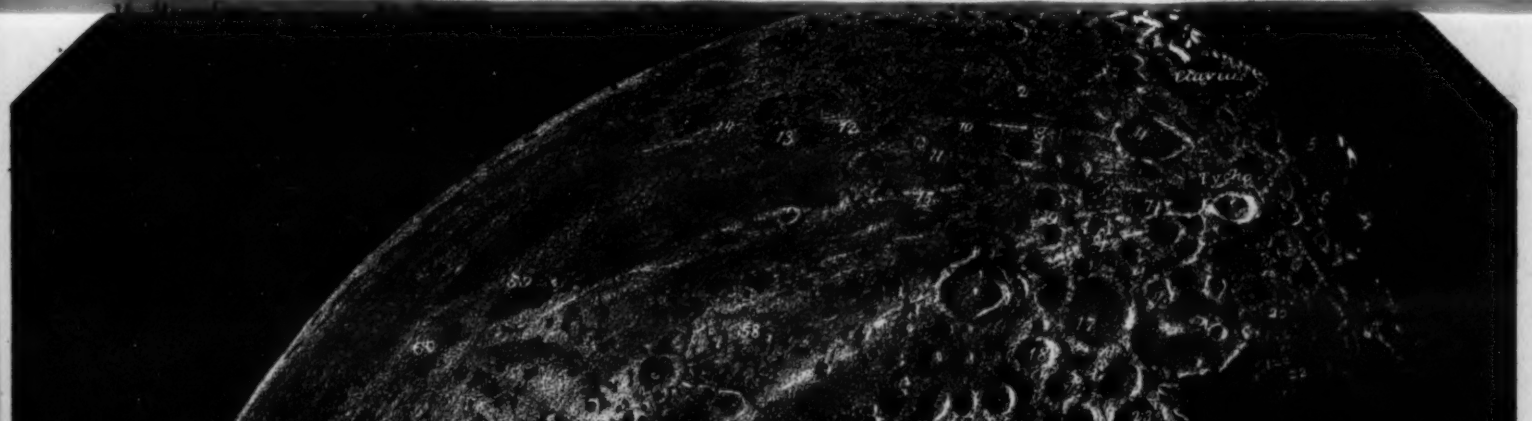
43. Aristillus.
44. Theœtetus.
45. Cassini.
46. Calippus.
47. Epigenes.
48. Anaxagoras.
49. Barrow.
50. Albategnius.
51. Abulfeda.
56. Playfair.
57. Apianus.
58. Picolomine.
59. Furnerius.
60. Petavius.
61. Fracastor.
62. Sanbeth.
63. Vendelinus.
64. Langranns.
65. Cook.
66. Gœlenius.
67. Guttemberg.
68. Theophilus.
69. Kant.
74. Agrippa.
75. Triesnecker.
76. Ross.
77. Vitruvius.
78. Palus somnii.
79. Macrobius.
80. Rômer.
81. Posidonius.
82. Bessel.
83. Linné.
84. Burg.
85. Hercules.
86. Atlas.
87. Endymion.



Photographic Map of the Moon

EASTERN HEMISPHERE

LECTURES ON VENTILATION.

By Lewis W. Leeds.

Second Course, delivered before the Franklin Institute, during the winter of 1867–68.

LECTURE I.

Perhaps no subject relating to the health of the human system ever gained favor more rapidly, (without advertising,) than has the subject of ventilation within the last year or two, and I think we may refer to the report of the Board of Health, for the year 1867, as a substantial and most gratifying proof of this assertion.

In the year 1865, there were 17,169 deaths in this city; in 1866, there were 16,803, and in the year 1867, there were only 13,903, or a saving of 2,870 lives in the last year, and 3,237 in the two years, and this, too, notwithstanding an increase of population probably equal to 20,000 per annum.

The saving to the citizens of Philadelphia by the diminished mortality, and the sickness represented thereby, could be scarcely less than three-quarters of a million a year; or sufficient to pay the entire expense of our excellent system of public schools.

Could this decrease in the rate of mortality be continued we would soon be a very healthy people; perhaps this is almost too much to hope for.

I do believe, however, that this rate of decrease in the mortality may be continued through the year 1868, and with a cash outlay, if judiciously expended, no greater than will be returned to us penny for penny and dollar for dollar within twelve months thereafter.

No healthy condition of the human frame can be maintained without we breathe pure air, and although there has been a wonderful improvement in this respect within the last few years, yet we still do not breathe pure air one-half our time.

Our arrangements for the artificial ventilation of our houses in winter and at night, are still exceedingly imperfect.

The great majority of our citizens scarcely realize the true value of pure air, or hardly know how to obtain it economically at all times. We need more public education on this subject.

There has long dwelt in the minds of many persons a kind of

vague idea that ventilation was a good thing in its way; but with nine-tenths of the whole people, the chief concern has been to *obstruct* all circulation of air, to stop all draughts, and thus practically to prevent any *ventilation*, especially in winter.

In the good old days of open wood fires, when, as in our childhood, the real chimney-corner was the family sitting-room, so to speak, or at least, for the children, then, with all the listing of doors, caulking of windows, and filling up of key-holes, there was certain to be still an abundance of fresh air, that would force its way into the room in spite of all efforts to keep it out. But with the introduction of anthracite coal and air-tight stoves, and still worse, steam-pipes, placed in the room for heating by direct radiation, the stopping of all draughts that were before so annoying, became a matter of easy accomplishment.

The results thereof have been perfectly frightful, persons have thus unconsciously been smothered to death by the thousands and tens of thousands.

It seemed almost impossible to arouse the public from the quiet, satisfied stupor that followed their great victory over their old enemy—the whistling winter wind.

Those that have not gone to their long homes during this dark winter-night of stupor and ignorance, may well rub their eyes in astonishment, as they awake to a consciousness of the dangers they have so marvelously escaped.

The poor man, too, as well as the rich, should feel that he has no truer or more valuable friend on earth than fresh air. His food, though coarse and simple, will digest more fully and quickly with an abundance of pure air. His head is clearer, his chest expands and his muscles grow stronger, as his heart grows lighter, and he goes cheerily on day after day with his laborious toil, returning at night to his home and fireside, surrounded by his wife and little ones, a happy man, made so by the consciousness of having been able to do and having done a good day's work. He enjoys a night of sound sleep, when sleeping with open windows, and wakes refreshed in the morning, ready again to commence the toils of another day.

The Doctor's explanation of the physiological effect of breathing air, whether pure or impure, is very interesting.

We cannot, of course, expect to go into a regular medical or physiological lecture at this time, but we must just examine some of the main points so as to get a general idea of the effect produced by air

of different qualities, and if possible, to form some conception of the manner of its action. I have here a little arrangement by which I wish to represent the action of the lungs.* It is simply a glass bell jar with a piece of rubber stretched over the bottom, which is intended to represent the human diaphragm. From the mouth of the figure-head there is a small tube extending downwards, and this represents the wind-pipe, at the end of this is another piece of rubber, which we will suppose to represent the lungs. Now, as I draw down the diaphragm, the space in the jar is enlarged, and a partial vacuum is created, and the air rushes down the wind-pipe to fill the space. It is prevented, however, from getting directly into the body by the lungs, which being elastic, or rather all folded up in innumerable little folds, expands and contracts with great ease. The power, therefore, does not lie in the lungs so much as in the diaphragm and ribs, the air is forced out and in the lungs, similar to the manner in which it is forced out and in a pair of bellows.

Fig. 1.

The lungs are composed of an immense number of air-passages, with innumerable branches, we might say, perhaps, like the branches of an apple tree, and at the extreme ends of these branches are air-cells instead of apples, the number of these little cells is estimated by some to amount to six hundred millions.

The aggregate surface of all these air cells is variously stated by different physiologists from 600 to 1500 square feet. So, if this room was 30 × 40 feet, the surface of the lungs of a single person would, if spread out, be sufficient to carpet the whole room.

These air-cells are perfectly surrounded by a complete net work of minute blood vessels, through which flows the dark, impure blood that has just returned from the most extreme points of the body, bringing with it, dead, diseased, old, worn out particles of the body, and the carbonic acid, or what we might call the ashes resulting from the combustion of the oxygen, which is constantly required to keep up the heat of the body.

Now, it is when this impure blood on one side meets the pure air on the other, that the most wonderful change takes place.

This membrane of these air-cells of the lungs is so exceedingly delicate, that there is a chemical transformation or exchange takes place at once.

The carbonic acid, and other impurities from the blood, pass

* Griscom's "use and abuse of air."

through this fine membrane of the lungs, and are absorbed by the air, while the oxygen of the newly breathed air passes through the lungs into the blood, which is thus changed from a dark color to a bright, light colored red, and oxygen is thus carried to the hundreds of little capillaries in the most remote parts of the body to the skin, and to the bones, to the brain and to the stomach, and there burned to keep up the heat of the system, and to cook the food we have eaten, (if the Doctors will allow me to express in that homely manner, the beautiful and very elaborate process in which the fresh air we breathe acts in digesting and utilizing our food.)

But suppose, instead of the air thus introduced into the lungs being pure, it is impure, or already loaded or charged with carbonic acid by previous breathing, then it cannot take up the impurities of the blood, and instead of its being changed by the absorption of oxygen to a beautiful bright red, it remains of a dark, dull color, consequently these impurities have to be carried back to all parts of the system, instead of the much needed oxygen; disarrangement of the whole system soon follows to a greater or less extent, according to the proportion of the impurities in that air.

The little air-cells of the lungs also become choked up with this refuse material, which causes what is familiarly called consumption. You all know if you allow the ashes to accumulate so as to fill the entire space underneath the grate, that the grate will soon be burned out. In a manner very similar to this will that exquisitely thin, delicate membrane of your lungs be destroyed, if you neglect to breathe sufficient pure air to carry away all the ashes from the immense number of fires constantly burning in your body.

The frequency of these interchanges between the air and the blood, the very large aggregate amount of each that daily passes through the lungs, ought to impress us with the great importance of a careful attention to maintaining the best conditions for perfect health.

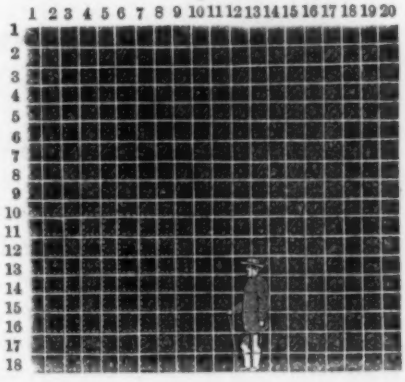
But, in too many cases, our estimate of the value of things is based upon the dollars and cents it costs us, and as no patented monopoly has ever been able to control the supply of pure air, so as to dole it out to us by the dollar and cent's worth, but it is kept constantly poured around and over our houses in the most lavish profusion, yet we have in many cases treated this wonderful bounty of the Creator with shameful neglect.

I have prepared a diagram by which I hope to impress upon your minds the amount of air breathed by each individual in twenty-four hours. It is 18 × 20 feet, and intended to represent one foot thick;

this gives 360 cubic feet of air, or 125 times the whole bulk of a man.

This, of course, is given merely as an average. The amount breathed varies very greatly from many causes,—some persons may breathe at times nearly double this amount, and at others not half so much. The average number of respirations are estimated at about 20 per minute, and the amount inhaled at each respiration is about 10 cubic inches.

Fig. 2.



We do not completely fill and empty the lungs at each breath, on the contrary, the lungs contain 150 to 200 cubic inches of air, so that about one-eighth only of the contents of the lungs is changed at each breath. I believe Physicians have scarcely determined positively how this air remaining in the lungs is quickly and constantly purified.

The diffusion of gases, which I hope to explain in our next lecture, has much influence, no doubt, in removing the excess of carbonic acid from the remaining air, and saturating the freshly entering air before it is inhaled.

Some physiologists explain, that the carbonic acid, and other impurities, are expelled from the minute cells by the muscular contraction of the circular organic fibres, and are thus delivered into the larger branches in which diffusion at once takes place with the air just introduced.

I wish to show you here what proportion of the air breathed daily is oxygen, as that is the very important element in the air. It occupies in bulk about twenty-one parts in the hundred, or a little more than one-fifth of the whole. The other four-fifths being mostly nitrogen. The use of this latter gas, the nitrogen, has scarcely been determined, it is thought by many to be merely a dilutent of the oxygen to keep it under control, so that it shall not take fire spontaneously, and burn everything up.

So much for the air we breathe; the blood, of course, continues the connection from the lungs to all parts of the body; and let us examine that for a few moments.

(To be continued.)

Franklin Institute.

Proceedings of the Stated Monthly Meeting, June 17th, 1868.

THE meeting was called to order with the President, Mr. J. V. Merrick, in the chair.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported that at their stated meeting, June, 10th inst., donations to the library were received from the Royal Astronomical Society, the Royal Society, the Institute of Actuaries, the Statistical Society, and the Society of Arts, London; and the Association for the Prevention of Steam Boiler Explosions, Manchester, England; la Société Industrielle, Mulhouse, France; the Canadian Institute, Toronto, and Major L. A. Huguet Latour, Montreal, Canada; his Excellency, Rawson W. Rawson, Governor of the Bahamas, through John H. Redfield, Esq., Philadelphia; Frederick Emmerick, Esq., Washington, D. C., and Hon. Wm. J. McAlpine, Stockbridge, Mass.

The various standing committees reported their minutes.

The report of the Resident Secretary on Novelties in Science and the Mechanic Arts was read, in the course of which a description was given of a new form of safety hoisting apparatus, invented by Messrs. Merrick Bros. A description and drawing of this will be found in our editorial department.

Mr. William Sellers, Chairman of the Committee appointed to report on the expediency of an Exhibition of National Industry by the Franklin Institute, stated, that in answer to an inquiry addressed to the Board of Managers by members of the Institute as to the reasons for deferring such an exhibition until after the fall of 1868, he had been authorized to explain, that the reason of this postponement was the conviction that the serious financial outlay which must be made by the Institute, in erecting a suitable building for the purpose of an exhibition (no existing edifice in the city being fit for the purpose), was not likely to be reimbursed by the receipts of an exhibition amid the excitements of the coming Presidential election.

The meeting was then, on motion, adjourned until the third Wednesday in September.

Bibliographical Notices.

The Lathe and its uses; or instruction in the art of turning wood and metal; including a description of the most modern appliances for the ornamentation of plane and curved surfaces; with an appendix, in which is described an entirely novel form of lathe for eccentric and rose engine turning; a lathe and planing machine combined; and other valuable matters relating to the art. Copiously illustrated. Published by John Wiley & Son: New York. For sale by J. B. Lippincott, Philadelphia.

A useful book, full of valuable information, very clearly expressed. We have examined it with care, and heartily recommend it to the professional mechanic as well as to the amateur. To the latter it is invaluable, but we are sorry to say, it has two grave faults. In the first place, while many of the wood cuts (of which there are about 500), are excellent, some are so poorly executed as to be but mere sketches of the devices described.

Then there is no index, in other words, what is pre-eminently fitted to be a work of reference, fails entirely to fulfil its proper mission, for lack of this simple but essential ingredient.

On one page, in reading the volume, we found the description of a method for soldering work to a face plate or chuck, by using sal ammoniac in solution, and tin foil, as the flux and solder. This is described as a useful "dodge." We naturally wondered if the writer was familiar with the much more efficacious soldering liquid chloride of zinc, and if he described how to prepare and use it. This led us to look for an index, but none was to be found, and then, loosing the page upon which the original useful dodge was given, we can only hope to find it again by a careful re-perusal of the book. We cannot too severely censure this carelessness, in issuing a good book (which is essentially a book of reference,) without a key to its contents. It is an imposition upon the public, and a serious injury to the actual value of the work.

We have ready, notices of the following new publications, which have been crowded out of this number:

Metallurgy of Iron. By Bauerman. *Gas Works of London.* By Colburn. *Lessons in Elementary Chemistry.* By Roscoe. *The Institutes of Medicine.* By Paine. *Instruction in the Practical Use of the Blowpipe.* By Plympton. *Mechanic's Tool Book.* By Harrison.